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MANUAL OF TOPOGRAPHY.

ENTHOFFER.

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MANUAL OF TOPOGRAPHY,

AND

TEXT-BOOK OF TOPOGRAPHICAL DRAWING;

FOR THE USE OF

OFFICERS OF THE ARMY AND NAVY, CIVIL ENGINEERS, ACADEMIES, COLLEGES, AND SCHOOLS OF SCIENCE.

BY

J. ENTHOFFER,

U. S. COAST SURVEY,

(FORMERLY OF THE IMPERIAL AUSTRIAN MILITARY GEOGRAPHICAL INSTITUTE, AND OF THE IMPERIAL RUSSIAN TOPOGRAPHICAL DEPOT.)

WITH AN ATLAS.

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PREFACE.

The art of topographical drawing, at the present time, is pursued only in military schools, with more or less assiduity, and in polytechnic institutions, as far as it is deemed necessary to enable the future field-engineer to represent a plan in outline. From what can be ascertained, it appears, however, that proper attention, if any at all, is not awarded in higher schools to this art: proper attention, we say, because we believe that no clear conception of the configuration of surface can be formed from the study of geography or geology, if these branches of science are represented by sketches of physical outlines on a small scale, such as from four to ten-millionth only. In profile-drawings these are sufficient; but a topographical plan, in order to show the true formation of a ground, must be drawn on a larger scale. In reduced maps the picture diminishes gradually into an abstract form, and deviates the more from the real the less the space given to the object. The purpose of a map will therefore always regulate the scale of its construction; and it is evident that, when the latter becomes so large that the use of conventional signs is no longer applicable, because of all objects appearing in their true outline, it requires superior abilities on the part of the student; besides a regular course of instruction and opportunities for practical improvement must be afforded him in order to attain usefulness and proficiency in the art.

Topographical drawing must go hand in hand with geodesy;

the latter determines the relative proportions of a part of the earth's surface, and the former represents the same in bird's-eye view. Both studies owe their cultivation to the importance of a knowledge of topography, which plays an essential part, not only in national economy, but also in the development and progress of nations.

The great usefulness of topographical knowledge in war is forcibly proclaimed in Greek and Roman annals. The art of surveying can be traced back as far as the Pharaohs; yet the art of topographical drawing remained in a state of imperfection down to the early part of the nineteenth century.

With the ability of manœuvring large bodies of troops, arose the necessity of a more exact acquaintance with the condition of the ground upon which they were to be moved. To this end Napoleon I. organized a distinct body, the *Corps des Guides*,* whose duty it was to examine the country in advance of the armies, and to make sketches and plans, which might serve as a basis for the position of troops. The art of topographical drawing, however, was rescued from its former vaguely-defined character by the Saxon major, Lehmann, first in 1811, and established on mathematical principles. From that time Lehmann's system, with slight modifications, has been introduced into nearly all European countries, and also into the United States.

If it is an undeniable fact that all strategic as well as tactic combinations are based upon an accurate knowledge of the organization of states and of the conformation of their territory, then the importance of the science of topographical design is sufficiently established, and it ought to be considered as one of the principal requirements of a military education.

* The engagement at Valeggio, 1796, in Italy, gave rise to the organization of the *Corps des Guides* in the French army; for, when Napoleon had established his headquarters near that place, some Austrian troops succeeded in surprising it, and the commander-in-chief escaped being made a prisoner only by accident.

Of no less importance is this science to the engineer who lays out highways, canals, railways, and cities. He who understands drawing correctly, and has studied the topographical relations of the surface, can alone form a true estimate of the value of a correct topographical drawing.

Not only to engineers and soldiers has this branch of knowledge become indispensable, but also to the learned in general, since it enables them to follow intelligently the graphic representations which accompany works of natural history.

The author of this work, well acquainted with the requirements of the soldier and engineer, and having gained his experience by a service of thirty years in topographical institutions of both the Old and the New World, hopes that he will be successful in supplying a want long felt. To this end the most prominent systems, those of Lehmann, Dufour, and Olsen, have been examined, and in the selection of illustrations the best surveys and maps have been consulted. Not content with simply presenting models for graphical imitation only, the work endeavors to direct the attention of the student to their physical and military significance in a brief summary.

In giving directions for drawing and copying the plates, it was deemed necessary to modify the method hitherto in use, in order to avoid, as much as possible, the technical difficulties which could have been overcome in the old way only by much practice and loss of time, and to facilitate the process by expedients, so as to enable the student to produce in less time not only correct but even well-executed copies.

With regard to the style and phraseology of the work, the author feels himself obliged to apologize to the public for certain Germanisms, which even sundry English scholars whom he consulted could not altogether avoid, without running the risk of misrepresenting the subject-matter described. This has been the more difficult, as the English literature has hitherto not been called upon to effect much in this branch of knowl-

edge; thus the all-important references to authorities do not exist. As the German literature is in this science so amply provided for, the author wrote the work in the first instance in German, for the sake of comparison; consequently he found how difficult it would have been to compose such a work in English.

He is indebted to many of his friends for kind suggestions, and thinks it proper to add some remarks by Mr. Noel Hope, who revised the work, on translating in general:

"Lamartine has somewhere said that, of all literary work, a translation is the toughest. The dictum is correct, for, not only must the translator have the idioms and genius of two languages at command, but, in order to insure perfection, he must be conversant with the subject under consideration.

"It is utterly impossible to avoid, *in toto*, giving a foreign aspect to the phraseology of a rendering from the German, unless a freedom be adopted which, in works relating to certain special sciences, is not permissible.

"Any one curious enough to compare the superabundance of words the German language luxuriates in, with the paucity of any other in this regard, need but to try his hand at a translation where science is concerned, to be convinced at once that the Teuton tongue is a grand old oak, the mere offshoots of which have become cognate dialects; and that, despite whatever beauties may be claimed for them, they are, nevertheless, one and all, vastly inferior to the parent stem."

J. ENTHOFFER.

WASHINGTON, D. C., *May* 1, 1870.

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INTRODUCTION.

TOPOGRAPHICAL DRAWINGS are not a complete representation of Nature, although, employed for plans of large dimensions, they rather offer an abstract picture of objects. To compare topographical drawings with Nature, in the same manner as other pictorial representations, is impossible, because a terrene* can never be entirely seen from any stand-point to the extent in which it is reproduced. This is, also, the reason why plans and charts are as so many unintelligible hieroglyphics to those who never have familiarized themselves with the means of topographical representation, or as are notes to those who do not understand music. This, of course, relates chiefly to representations *en relief*.

The objects of a topographical representation in horizontal projection are threefold:

Economical, for buildings of large extent, fortresses, harbors, etc.

Political, embracing a whole state or country, its divisions, etc.

Military, if for tactical or strategic purposes. A drawing is called a *map*, or *plan*, if the scale is large enough to admit all objects in orthographic projection; but, if objects are represented by characteristic signs, it is called a *topographical reduction*. If the representation embrace entire tracts of land, exhibiting the configuration of the surface in its relation to the whole, designating settlements by conventional signs, according to their respective political significance, it is called a *chorographic* or *general map*; and, if the elements of the formation of surface be so much reduced

* We shall frequently use the word "terrene," which is derived from the French word *terrain*, and signifies earth, ground, or soil. In military language, however, it denotes the surface of the earth, and has particular reference to the configuration of the ground, such as depressions, elevations, etc.

that no more than the geographical direction of the same is represented, it is a *geographical map*. *Field sketch* (croquis) is the name used for small surveys sketched by the eye (*à coup d'œil*), for military purposes. *Itineraries* are the results of travels, on which objects to the right and left of a route are depicted from observation; but all objects farther off, from information afforded by inhabitants or travellers.

Hydrographic charts are those made for purposes of navigation; these are subdivided into ocean, coast, port, anchorage, and river charts.

Geographical drawings which serve as compendious maps for special scientific purposes, such as astronomy, physical geography, etc., are in general designated as cosmographic charts or maps.

Drawings and illustrations contribute much to an easy comprehension of scientific treatises, and in no other way can a comparison be made so clear, for, where description employs a multitude of words, the picture conveys, at a glance, a ready comprehension of the objects.

PREPARATORY STUDIES.

In order to pursue topographical drawing with a proper understanding, the study of descriptive geometry should precede, or, at least, accompany it. The next desirable accomplishment is some progress in off-hand drawing, by which not only the sense of form is developed, but also its recognition and reproduction are greatly facilitated by the skill of hand and eye, enabling the student to represent it either in its characteristic features or its direct circumscription. Wherever this preliminary knowledge and skill are found, but little difficulty will be experienced in graphically delineating the configuration of the surface of the earth.

We may be permitted here to remind the student of the great importance of economy of time, as in no other kind of instruction is time so often wasted as in the practice of drawing. Every teacher of this art should make himself familiar with the method of the late Professor Waldmüller, of the Academy of Fine Arts, of Vienna, published in a memorial of the progress of the class under his direction, which has been crowned with surprising success. Professor Waldmüller justly observes, that copying from

drawings, engravings, or models in plaster, is but lost time, and will forever be only a mechanical imitation, that the genius of an artist cannot develop until directed to the study of Nature. *Why not, then, directly appeal to the sacred fountain of truth?* "Nothing," he says, "is more appropriate for the beginner in art than the human figure, which should not form, as many intend, the last stage of artistic instruction. Nothing can be so well known to man as his own form; no subject in the universe can be more familiar to his comparison; for, in the cradle, the child already distinguishes a stranger from those who every day surround it." Thus, it is evident that the study of the art of design ought to commence with the human face, because it is supported by the earliest and best-developed faculty. In order to set well about his undertaking, Waldmüller begins with the solid frame of man; first, the skull, then the order of muscles surrounding the same. After these are fully understood, he introduces the living features, the face, and, proceeding, follows the same system with regard to other parts of the human body. Here, some will say that "this may be a proper way for the student of historical or portrait painting, but not for the soldier or engineer, who only wants a little practice in off-hand drawing." This objection will be removed on considering that the preliminary object of design, the faculty necessary for our study, is a developed sense of form, an ability to reproduce the objects of observation in such a manner that they can be easily recognized by any one, which cannot be attained but on the basis of an awakened faculty for distinction, which, by proper instruction and rational comparison, can be trained at an early age, through forms constantly present to the eye—even by the sight of ourselves. Is there any object in Nature surrounded by more delicate and glorious contours than the human face?

A course in drawing, after Waldmüller's method, will be sufficient to give the student all requisite skill in the use of hand and eye, so that he may carry on all operations connected with topographical design, as well in regard to conception as to reproduction.

LITERATURE.

The present work is mainly intended to serve as a guide to topographical drawing, and therefore the chief point of attention has been to furnish examples which, in their characteristics, con-

form strictly to Nature. Wherever it appeared necessary to illustrate the prevailing system of orographic drawing, Lehman's well-known model has been selected, because it is best adapted to our demonstrations, and affords convenient comparisons for those who are already, to a greater or less extent, familiar with the subject, as hereby the progress made can be ascertained.

The topographic draughtsman should not attempt to invent new conventional signs, but always follow those which have been universally adopted. As sources for conventional signs, we have consulted "Mémorial Topographique et Militaire, redigé au Dépôt Général de la Guerre," as well as that excellent work, "Pilot de France," and the rules and formulæ of the Imperial Austrian "Generalquartiermeister Stab," and also the rules for representing certain topographical features of the U. S. Coast Survey.

As a manual of topography, this work makes no pretensions to perfection. It would, for our present purpose, be too great and comprehensive a task to collect the many discoveries and long experiences displayed in this field in a work suitable for the use of officers and engineers, and for instruction generally.

The following works have served as sources of information:

Lehrbuch der Geognosie und Geologie, by R. C. v. Leonhard.

Characteristick der Felsarten, by the same author.

Lehrbuch der physikalischen Geographie und Geologie, by B. Studer.

Der Gebirgsbau der Alpen, by E. Desor.

Die Gebirgsgruppe der hohen Tauern und die der Oetzthalergruppe, by K. v. Sonklar.

Système Glacière, par L. Agassiz, A. Guyot, and E. Desor.

Travels of the Alps, by J. Forbes.

Elements and Principles, by Sir Charles Lyell

Terrainlehre, by Dr. F. A. O. Etzel.

Terrainlehre, by F. v. Dürich.

Terraingestaltungen, by Frh. Ph. Reichlin v. Meldegg.

J. Scheda, Leitfaden im Situationszeichnen, mit Atlas.

Schintling, die Terrainaufnahme.

A. Sydow, Planzeichnen.

PART I.

MATERIALS, INSTRUMENTS, ETC.

DRAWING MATERIALS.

Paper.—The Whatman drawing-paper is generally used, the Bristol-board but seldom. The former has a rougher surface, and on that account imparts a soft expression as well to the drawing as to the tone of the coloring; while the latter, on account of its smoothness, exposes the least unsteadiness and insecurity in the strokes of the pen, and the coloring appears blurred, if it be not done with a master-hand.

Lead-pencils.—For sketching contours, Faber's No. 4 is the best, and No. 3 for the drawing of auxiliary curves, because these must subsequently be removed.

India-rubbers, or erasing-rubbers, can only be used with the utmost care. When the drawing is finished, crumbs of stale bread are the best means to clean off every particle of dust, as well as to efface any superfluous lead-marks.

Pens.—Gillott's crow-quills and lithographers' pens serve best for the express purposes of drawing.

Indian-Ink.—The best Indian-ink is the Chinese; when faintly put on, it displays no spots, and has a warm, brownish hue, and, if used in a liquid state, is easily washed off, but stands fast when dry. The cup, while in use, must be shielded from dust; a paper cover, with an opening at the side for the pen, answers best for this purpose.

Colors.—Water-colors, which are transparent, are the only ones fit for topographical drawings; as Prussian blue, carmine, gamboge, warm sepia, burnt sienna, or Vandyck-brown; of verdigris and Berlin blue dissolved in a liquid form, however, as they can seldom be obtained in a prepared state, the mode of preparation is here given: Verdigris is distilled in clear water, in

the sunshine or some other warm place, and, when sufficiently dissolved, is mixed with cream of tartar, and then poured off clear. Should vinegar be used as the solvent, the paper will be injured. This color is used in a much-diluted state for grass, and mixed with gamboge for orchards or vegetable gardens. Berlin blue is rubbed off finely with vinegar, dissolved in equal proportions with muriatic acid, constantly stirring the mixture until it becomes cool, and the rising bubbles disappear. The thickened mass is now treated with distilled water and gum-arabic, until it becomes sufficiently liquid, and then put away in well-corked bottles. This liquid blue is used for outlining all hydrographic contours.

Brushes.—The so-called wash-brush is the best; the principal quality of a good brush is, that its extremity, even when moistened in the least degree, does not separate.

Drawing-pins.—The finer the points and the flatter the heads, so as that the ruler may move over them without difficulty, the better the kind.

Stretching.—In cases where greater surfaces are to be put in color, the paper must be stretched upon a drawing-board, in order to prevent shrinkage. The most simple method of stretching paper is as follows: The paper, with its smooth side upward, is laid upon the board, the edges of the paper being folded over, according to its size, from a quarter to half inch; then the paper is turned, and moistened with a clean sponge; and, when this is uniformly done, the paper is again turned and placed at right angles with the board, and the edges are now fastened down with glue. Never place the board near a stove, nor expose it to the warm rays of the sun, but leave it to dry in a flat position.

For topographical drawings, paper pasted on cotton is commonly employed, in order to protect it from tearing.

INSTRUMENTS.

These include, besides a case of mathematical instruments, a T-square, two parallel rulers, and a curvilinear ruler; if the case contains no beam-compass, one ought to be procured. The use of roulettes, lithographic needles, and polisher, will be explained at the proper place.

TECHNICAL FACILITIES IN COPYING TOPOGRAPHICAL DRAWINGS.

Every topographical drawing has first to be sketched in its outlines; this has hitherto been practised as follows: The original

is divided into squares, or, where figured on a sheet of glass, in order to preserve the original from marks and dust, these squares are drawn in pencil on the paper, and then the outlines sketched in, square by square. Only after this tiresome and tedious labor has been performed can the finishing work begin. Meanwhile the paper frequently becomes soiled, nothing is learned, and discouragement and disgust only ensue.

This evil can best be avoided, if the draughtsman proceeds in the same manner as copperplate engravers do, in preparing the tracings according to their system; and then transferring them on the paper; this is done in the following way:

A piece of so-called gelatine-paper is laid over the original design, and the outlines are traced with a fine and very sharp needle (finest sort of lithographer's needle). Since the transfer thus taken must be reversed, in order to permit its copying in the manner hereafter described, the student should turn the gelatine-paper and trace the outlines over again on the reversed side (for practice alone this is unnecessary). This last sketch is then rubbed over with the aid of a piece of soft leather, dipped in color-powder or lead-dust; the surplus lead is then removed, and the gelatine-paper now placed upon the sheet, and finally printed off by pressing carefully with a polishing-steel. The perfection of the copy particularly depends on this operation. Where frequent use is to be made of one and the same tracing, as may be done to advantage with classes, the reversed side of the gelatine must be passed over with a small rag dipped in oil, to counteract the scratching of the surface by the polishing-steel; the gelatine thereby becomes elastic, and better adapted for repeated use.

During the process of transferring, the sheet should rest upon a glass or metal plate; a support yielding to pressure would inevitably tear the gelatine.

Where a copperplate or lithographic printing establishment is accessible, a copy may be procured on the press, which of course gives a better result. The outlines of a drawing, transferred by means of gelatine-paper, possess every advantage over all other methods hitherto employed—the drawing is accurate, distinct, and clear

SCALES.

The proportion of scale is regulated by the object of the drawing, which may be either—

1. Review of a limited terrene, or of the surroundings of a

locality, for the purpose of placing troops in position, for military manœuvres, a battle, blockade, or siege.

2. Review of a larger terrene for purposes of single operations, for moving troops in war or peace, for location.

3. Review of entire provinces or countries for purposes of arranging extensive military operations, etc.

In forecasting these different categories, the following rules should be observed:

a. That the orthographic projection, or, where this is no longer practicable, the character of any object represented, can be plainly distinguished by the naked eye.

b. The relations of the various parts of the terrene must not be represented with more detail than the object in view requires.

c. All topographic drawings should be executed in such simple relations to the customary measure of length as will admit of practical estimates of distance by the eye with a certain degree of accuracy.

A definite rule for each of these categories cannot well be given, because the configuration of a terrene will always have a decided influence upon the scale, in order to its proper representation.

The following scales are generally adopted:

For agricultural surveys, from $\frac{1}{2500}$ up to $\frac{1}{10000}$, natural size.

For topographical surveys, from $\frac{1}{10000}$, $\frac{1}{15000}$, to $\frac{1}{25000}$.

For topographical maps or charts, from $\frac{1}{20000}$, $\frac{1}{40000}$, to $\frac{1}{80000}$.

For general maps, from $\frac{1}{200000}$ to $\frac{1}{400000}$.

In every plan or chart, whatever be its object, the scale must always be indicated.

PROJECTION.

The kind of projection to be selected for any map depends altogether upon the particular purposes for which the map is to be employed. If only a topographical representation of a small portion of the earth's surface is intended, we may employ simply a rectangular system of lines, in which the equidistant horizontal ones shall represent circles of parallels or latitudes, and those at right angles, meridians; or we may draw the meridians converging, having ascertained the length of, say, one minute of arc for the upper and lowermost parallel of latitude. The distance of the parallels will be constant, and is to be taken from tables prepared for the purpose. Within the limits of a few square miles of area,

or of a single plan-table-sheet, the above process will answer; but, for any greater extent, that covered by a county or State, for instance, and if only a small amount of distortion is allowable, a more elaborate projection becomes necessary. Respecting the selection of the kind of projection, the reader may be referred to one of the many special and excellent treatises on the subject; and it is only proposed here to refer to the so-called polyconic projection as employed in the United States Coast Survey, on account of its general adaptability and simplicity of construction. Starting with the ordinary conic projection on a tangent cone, whose radius is the distance between the middle latitude and the intersection with the earth's axis, and having all parallels of latitudes equidistant (according to tabular length of intervening arc) and described with the same radius, we readily see the slight modification required to improve this process by the employment of a number of such tangent cones, which at once leads to the polyconic projection, which may be described and used as follows: Let a vertical straight line, through the middle of the map, represent the middle meridian; lay off, according to scale and from the tables, the length of minutes or of degrees of arc, as the case may be, and mark on the line the corresponding degrees and minutes of latitude; next, take from the tables the radius of curvature for each of these points, and draw arcs of circles through them, extending right and left to the border of the map, the upper (in higher latitude) circle will have more curvature, and the lower one less curvature, than the middle one. If, as is usually the case, the radii are too great, on the scale, to be directly employed, the parts of arcs for each division of latitude must be constructed by means of coördinates, for which the elements should be contained in the tables. A series of arcs representing parallels being thus constructed, the longitudinal divisions according to scale, and taken from the tables, must be marked upon them, and will generally suffice to mark off the true length of minutes or degrees (as the case may be) on the upper, middle, and lower arcs, and connect them by slightly-curved lines, which will be found concave toward the middle meridian; these curves, which for small extents of surface appear straight, will represent the meridians.

A full description, accompanied by the necessary tables for constructing maps of a few square miles, as well as of a continent, will be found in the publications of the United States Coast Survey Reports of 1853, 1856, 1859, and 1865.

The advantages of this projection may be stated as follows: A comparatively small amount of distortion, even at the borders of the map; a scale of minutes or degrees, as the case may be, of the meridian and of the parallels, in their correct relation, by means of which, with the greatest facility, positions, given by their latitudes and longitudes, may be inserted on the map; further, the parallels and meridians intersect so nearly at right angles that, for smaller areas, the distinction is hardly detected by the eye; and, even for a map of North America, is yet sensibly true. This projection admits, to a great extent, of the use of a linear scale in any direction, and for various parts of the map.

PART II.

OF LETTERS USED IN TOPOGRAPHICAL DRAWINGS.

All nations of Europe and America have adopted the Roman letters for describing topographical maps and charts; the Russians, Greeks, and Turks, are the sole exception.

The principal outlines of Roman letters, which are of Greek origin, have undoubtedly an architectural type, so that we are tempted to conjecture the original form of the alphabet to have been developed from some geometric figure, as in the case of the Arabic numbers; paleography (history of letters), however, contradicts such a supposition, and recognizes in the Canaanitic alphabet the first source whence the present system of letters is derived.

It appears beyond a doubt that, by the frequent application of letters in monumental works, the sculptors gave great improvement and finish to their form. There is a vast difference between sculptured letters of antiquity and coins of the same age, in favor of the former; these correspond more to handwriting, while those evince more symmetry in aiming at better proportions.

Attempts at deriving the fundamental features of the alphabet from a geometric figure, have no difficulty in so far as their characteristic form admits of bringing all letters into one figure, in which the analogous parts are congruent; but nothing is gained thereby in regard to the law of proportionality in their parts, being in accord with the æsthetic form of each letter, and the harmony of the whole. This law finds a thorough exposition in the "theory of the proportions" of the human body, morphologically, from a principle pervading all nature and art hitherto unknown, by Professor Dr. A. Zeising, Leipsic, 1854, Rud. Weigel.

By the help of an æsthetic law it is easy to give the student a key for the construction of the various kinds of written letters, employed in topographic description, whereby he may acquire

security of hand in their execution, which had to remain a matter of uncertainty as long as discrimination of beauty in form depended altogether on the individual taste.

Whatever in the above-mentioned work appears necessary to our present purpose, we shall reproduce here.

PROPORTIONALITY IN A SPECIAL SENSE, AND THE PRINCIPLE OF PROPORTIONALITY IN GENERAL.

The perception and definition of regularity and symmetry have never caused any particular difficulty. The fundamental law is equality of division of form, if not of all parts, at least of opposite parts. Whether a figure is in harmony with this law, or is not, can easily be ascertained, if necessary, by measurement, so that the artist, in representing a regular or symmetrical figure, can never be at a loss. Thus the first degree of formal beauty needs no special investigation.

It is different with the law of proportions. This is not the knowledge of the unity and connection between *equal*, but *unequal* parts of a whole. It should explain why, in respect of two things, each in a different manner divided into unequal parts, we call one beautiful and not the other; it should define the limit, in the inequality of parts, at which one part appears too great, the other too small, and the proportionality of the parts to each other and to the whole is disturbed. The difference between two unequal parts may be infinitely great or small, and a solution of the inquiry renders a diversity of opinions possible, with which neither practice nor science can be satisfied; it is therefore necessary, for the appreciation as well as the production of beautiful proportions, to have a fundamental rule in regard to the measure of unequal parts, since nothing definite can be said or done without such a law of proportionality.

A law on proportionality, to be generally accepted, should avoid the fruitlessness of mere generality, as well as the arbitrariness and hazard of details. It should be in intimate and absolute harmony with the general laws of beauty, as well as with beautiful appearances separately considered; it should be supported by reason, as well as by experience, and, though necessarily universal, yet fully define specialties, thus combining practical usefulness with a rational theory; i. e., if the division of a whole into unequal parts shall appear proportional, the measure of the smaller part should be to that of the greater part as the measure of the greater part is to that of the whole.

The geometrical demonstration is shown in the annexed diagram. A line of any given length, $a\,b$, will give the measure of two proportional parts in this manner: draw $b\,d = \frac{1}{2}\,a\,b$ from the point b in a right angle; draw the hypothenuse $a\,d$, and make $e\,d = b\,d$. Lay off $a\,e$ on $a\,b$, which forms $a\,c$, then $a\,c$ is the proportional greater, and $b\,c$ the proportional smaller part of the line $a\,b$, or $b\,c : a\,c = a\,c : a\,b$.

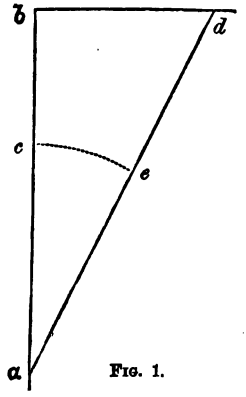

FIG. 1.

Mathematicians call this division: the division of the exterior and middle proportion, or the "golden cut."

The human body has always been considered the ideal of most perfect proportion, and the discovery of the law which forms the basis of its proportionality has been the central point of the entire question. The Pythian Apollo of Belvedere harmonizes most wonderfully with this law, and, both in regard to perfection in its execution, and harmony in its proportions, is, among works of art, the acknowledged ideal of manly beauty. (See Table I.)

In regard to the parts of the human body, we first contemplate its length, or height: Construct a perpendicular line, $A\,U$, representing the total height of the human figure, and divide the same into two unequal parts, according to the rule of "the golden cut." The shorter section, $A\,J$, corresponds with the length of the upper body, from the forehead to the navel, the longer section with the part from the navel to the soles of the feet. We should here observe how the rule is applied to the two main portions of the human body. For the sake of comparison, Professor Zeising divides the whole length of the body into 1,000 equal parts, and how they correspond in their proportion; also how the most striking curves in their outline verify this rule, as well as the different parts formed by natural division.

At the upper half of the body the neck strikes first upon the sight, at the lower half it is the knee which is the most evident segment. If the four sections now found are subdivided on the same principle, a glance at the human figure will show that the points of division fall always on the line of a projecting detail of the limbs.

Next, considering the width of the body, which equally with

length is in harmony with the laws of symmetry, some general observations should be premised in order to demonstrate the proportion of length and width.

This cannot be arbitrary in the formal beauty of a figure, since even abstract figures in geometry, at the sight of which the mind is entirely free of teleologic notions, and which, independently of their varying length and breadth, are not otherwise distinguished, possess a greater or less æsthetic value. If, for instance, of two oblongs, the entire difference of which consists in the various proportions of their length and width, one pleases and the other offends the eye, the reason of this diverse effect can only be explained from the nature of their proportions; and here, as well as in the division of the vertical dimensions, the question arises: What must be the relation of length and width in a figure, to constitute its formal beauty? The answer must naturally be the same as was given before in respect of proportions in general, and may be expressed as follows:

1. The shorter dimensions must be in proportion to the greater, as the latter is to the sum of both.

2. The breadth must be in a lawful proportion to the length or height of the figure.

3. The different parts of vertical extension must be equally proportional among themselves.

The greatest width measured by the body, is the distance of the arms stretched out horizontally, which, as is well known, measures between the tips of the fingers very nearly the same as does the total height of the body. For our purpose, we shall omit the fraction, and therefore take it equal to 1,000 parts, as we shall also do for the length of the body.

Above all other members, the arms here appear as the horizontal axes of the body; for in this position they form, including the two nipples, from the centre of the breast, two perfectly proportional and symmetrically constructed halves.

For the purpose of this work it appears unnecessary to enter into further details, in order to apply the proportions, or æsthetic relations, of the parts of the human body to the parts of letters.

It should, however, be mentioned, that Professor Zeising does not confine himself, in demonstrating his theory of proportions, to the relation of the parts of the human body, but deduces further illustrations from organic and inorganic Nature, ascending from the less *complete* to the more *finished* developments of symmetry,

and indicating their agreement with our ideas of beauty, as well as with the recognized masterpieces of sculpture and architecture, in ancient and modern times.

How far the proportions of the human body are applicable to the form of Roman letters, we leave to be decided by the judgment of all who construct with us their entire order, as contained in Plate No. I. Certainly it was a happy idea to derive the symmetrical proportions of letters in all their parts from the same law which regulates those of the most perfect form created —that of man. We will not censure, as lacking in poetic ideality, those who find no delight in comparing the symmetry and proportionality of the parts of letters with those of the human limbs; yet we must warn them not to depart from the rule of the "golden cut" by any change in the form of letters they desire to introduce. Arbitrariness in form may be excused in a current handwriting, but not in printed letters, the position, proportion, symmetry, equality, and harmony of which, are essential conditions that nobody can contradict. If the same conditions can be drawn from a general law, the application of this law to the form of letters is not only justifiable, but necessary.

CONSTRUCTION OF MAP-LETTERS.

Roman Capitals.—Of rectilineal letters there are 15, and 12 of these can be formed exactly within a square; i. e.: Construct a perpendicular line, $A\ U$, as in Plate I., Fig. 1 (it is unnecessary to copy the form of Apollo; showing the proportional relations being all that is required); divide this line, after the rule of "golden cut," in two proportional main divisions, so as to have the minor part, $A\ J$, above; then, marking always the minor on the major part belonging to it, until all divisions of height have been obtained. These modula of height contain at the same time the measures of width, since the latter have the same proportional relation, and in part consist of a twofold, threefold, or any other multiple of the same.

In the form of letters, as a general rule, the width is considered equal to the length, $A\ Z = A\ W$, and on the middle line, to the right and left, 90 units are laid off, corresponding exactly with the width of the trunk of the body proper, and with the average width of the upper legs. This measure represents the width of the column in a letter, which is only twice in the alphabet, in T and Y, placed in the middle of the square of construction.

Since writing is done from left to right, the natural position of the letter-column, as the main basis of the alphabet, is on the left. Lay off now, from *A* to *c*, 55 units (equal to the toes), and from *c* to *u* 34 units (equal to the instep, and both together forming the foot proper), from *u* to *w* 180 units.

The breadth of the hair-line is measured by the breadth of the hair on the forehead, from the beginning of the scalp to the crown of the head, which, according to the example given in Fig. 1, is equal to 21 units.

The diagonal shafts should at least apparently satisfy the demands of symmetry; this, however, cannot always be attained by an equal distribution of measurable proportion alone, but also by a consideration of the optical effect on the eye.

Space would not permit an explicit explanation on every detail; the instructor must begin the normal construction of letters, and by a thorough examination familiarize himself with the points and lines of construction in the table.

The points and hooks on the upper line are shorter and more contracted than those on the base line, according to the proportions of the human body. All curvatures of the hooks, as well as the points, are elliptic; the short and long axes are found as punctuated lines in Fig. 2. The method of constructing these curves will be explained in connection with the larger oval forms. The mutual relation of the axes is that of the "golden cut." The letters *M* and *W*, the latter a double letter, extend beyond the square, and consequently their outlines are not congruous with those of any other letters; for this reason, a second square has been constructed for their illustration. It seems unnecessary to further particularize the mode of construction in this second square, since drawing alone will enable the student to perceive that the same laws are followed. The student can examine the proportions, compass in hand, after having previously practised on two or three letters, and will finally retain the result of investigation better than could be done by a given description.

Elliptical Curved Letters.—These are *O*, *Q*, *G*, *C*, and *S*. Their construction is very simple: The centre-line, *X*, forms the longer axis, and the shorter is found by laying off on the middle horizontal line 45 units beyond the exterior outlines of the whole width; from this point, instead of 180, lay off 190 units as the thickness of the shaded line, for, if the normal thickness of 180 were taken, the shaded lines, being of a maximum thickness only in one point of

the circumference, appear by far too slender in comparison with those of other letters, on account of their gradual diminution toward the upper and lower line.

A mechanical procedure is sufficient to construct these elliptics, i. e.: If *a b*, in the annexed figure, were one-half of the longer axis, and *b c* the shorter axis of an elliptic, lay off *a b* on a small piece of paper, then apply this to the shorter axis, so that the point *a* exactly covers the point *c*, and the difference *b d* gives the *modus operandi*, by moving the point *c* toward the point *a*, and keeping the two points of difference exactly on the two axes *a b* and *b c*.

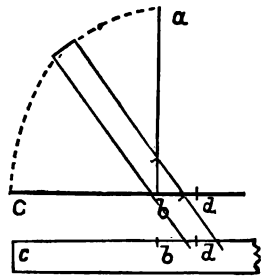

FIG. 2.

In this process the point *d* of the difference will move on to *b*, and the mark by *b* upward along the line *a b*; by this movement the point *c* advances to *a*; of course, in describing the curve from step to step, marks have to be made in that direction, and these marks must then be connected. After this simple manner, all elliptic curves found in Table I., Fig. 4, and elsewhere, have been constructed.

Having constructed *O*, the portion to the left gives the shaded line for *G*, and the portion to the right that for *D*. The upper end of *G* is exactly the same for *C* and *S*, and of the same distance as the hook of *E*.

The construction of the many curves of *S* by hand, renders this one of the most difficult letters, as has always been the case, because no definite rules or directions could be given. Some have maintained that the letter *S* should be constructed from the figure 8. Any attempt to form this letter by aid of the compass is faulty in principle, because the whole alphabet, in order to remain in harmony, which the curved line of beauty requires, admits of no circular lines.

To construct this letter, lay off on the perpendicular, *X*, from the horizontal line of *J* downward, 185 units, as the maximum of the shaded line, which also must be thicker than the perpendicular shafts of straight letters, on account of its gradual diminution toward both ends. A glance at Fig. 4 will convince the student that the large elliptics are situated between *X* and *e*, and between the horizontals, *J* and *U*. Special auxiliary axes must be constructed for the inner curves, that dwindle into hair-lines; namely,

for the upper portion, axis 1 to 4, which proceeds in the form of a radius from the point *i*; and, for the lower portion, axis 1 to 3, proceeding from the point *q*.

The letter *C*, though in its shaded line half an *O*, would come out of proportion in its hooks, i. e., the curve would seem broken, unless the axes are moved forward to obtain the requisite undulation.

Letters of Curved and Straight Lines.—To these letters belong *B*, *P*, *R*, *U*, *J*, and *D*, all in Fig. 4.

Excepting *J*, all commence with a shaded line on the left, the construction of which is now familiar; it is, therefore, only necessary to find the dividing line for the articulated shade-line in *a*. If this dividing line were exactly in the middle, the resulting optical effect would make the upper portions appear larger, contrary to the canon of the beautiful. A glance at the statue discloses that the proper dividing line is in the termination of the trunk of the body.

The upper curve, according to proportionality, must be narrowed, and also somewhat more delicate, than the lower one.

The letter *P*, though having but one curve, prefers the larger curvature, in order to maintain harmonious equipoise with the other letters.

The doubly-curved lower part of *R*, like *S*, is composed of various elliptic curves, the proportions in the axes of which have already been made known.

J and *U* have the only shaded lines terminating at the lower end in a curve; they have in common the turning-point of the lower curve of *B*, with this exception in *U*, that it is turned in an opposite direction.

Construction of the Roman Small Letters.—In order to establish harmony between the capital and the small letters of the alphabet, the latter must be constructed upon the same laws of proportions as the former. The major portion, *J U*, of the size of the letter being given, furnishes the height of the small alphabet, while the minor part, *A J*, gives the measure for letters having upper or lower portions. The outlines for the construction of these letters follow exactly the same principle as the capital letters, with the exception of a few letters and a few parabolically connecting hair-lines.

The forms of many of the small letters are either identical with those of capitals, or so nearly related, that, to particularize their deviations, appears unnecessary.

Construction of Stump-letters.—This class of letters is distinguished from the above by having the shaded lines curved at both ends. This leaves now only to explain how upright letters may be constructed in an inclined position, which is done in the following manner:

Various instructions are given for finding the angle of inclination; in order, however, to remain true to the law of proportions, we adopt the small *cadede* of the minor portion of the size of letters, as given as the standard of height, while the hypothenuse thus found affords the desired inclination, corresponding to an angle of 23 degrees. All horizontal distances should now be laid off on the inclined line; the elliptically-curved lines acquire a freer undulation, as appears most prominently in the letter *s*.

Construction of Figures or Numerals.—Numerals are subject to the same laws of proportion as letters; with this distinction, however, that, in order to give them a more slender appearance, like that distinguishing the female from the male sex, the thickness of shaded lines is taken at 165 units, instead of 180, or at about $\frac{1}{7}$ of their height.

The alphabetical and numerical letters represented on Plate II., with the exception of the bastard letters, were all reduced by photography from the constructions Fig. 1 to 8 in Table I. The result of the system here applied is, that all alphabets maintain harmonious proportions. Whether the letters have obtained the best possible æsthetic form, or whether they might be improved by discovering other proportions, is left to the assiduity of others.

Being now acquainted with the proportionality of letters, the exercises of Plate II., as is shown on the left side before the larger letters, require the drawing of auxiliary lines; the inclination of the letters should first be marked in lead-pencil lines, equidistant from one another, as the two shaded lines in the letter H, which distance may be considered as settling the rule for the so-called "spacing" of letters.

With so many auxiliary lines the student can readily sketch the forms of letters in pencil. The execution with pen and Indian-ink should begin by first making the hair-lines; next, those shaded lines which may be accomplished by the single pressure of a broad pen. This is undoubtedly the best method, and insures neatness and equality, as well as the greatest security and facility in writing.

MAP-LETTERING.

The various kinds of letters given in Table II. are used for description on topographical maps and charts; the bastard letters are applied only in France, Italy, and the South-German States.

The selection of this species of letters and their size depends on the permanent and general interest, the relative importance of the subject to be described, and the scale of the map.

The position of names should, as far as is practicable, be placed on the right of the object described; if, however, it would interfere with some important topographical detail, the name should be placed above, below, or even on the left, of the sign. When the locality to be described comprehends a larger space, as, for example, the scattered houses of villages in mountainous countries, the name may stand in the centre of the village, with spaced letters.

The main principle is, always so to insert names that any doubt or error may be avoided, and for this purpose neither the beginning nor the ending of a name should touch any object entitled to a special designation.

The names of valleys and waters, if practicable, should lie in the direction of their course, and in this case inclined letters are preferable.

Giving prominence to letters by massive shading, as a means of greater distinctness, has been erroneously substituted for names situated in the midst of a heavy declined slope: of course the visibility of such a name is endangered by the heavily-increased *hachures* surrounding it; this is erroneous, because greater distinctness is thereby sacrificed; for increase of size in shaded lines of letters is gained at the expense of the connecting hair-lines, which are the distinguishing characteristics between *n* and *u*, *c* and *e*, *B* and *R*, etc. Such massive letters are then so much obscured, that in places of heavy hachured slopes they become entirely illegible. This evil is not to be prevented by leaving the space around the word white, as such spacing would lessen the expressiveness of the design, without securing greater legibility of the name.

The purer a well-proportioned form of the letter is preserved, the more legible it becomes; and an accidental point or line passing through a letter, coming into contact therewith, cannot readily lead to error.

If the hachures are so heavy that they equal in width the shaded lines of letters, the best remedy is to execute between the

letters a fine narrow shading, in the same direction as the inclination will require. Lettering treated in this manner will not lose in distinctness.

The distance between letters, called *spacing*, requires a well-skilled eye, and this can be attained by practice only. A general rule for spacing is, on larger scales, the distance of the shaded lines from one another. Universal taste has long since decided in favor of such apportionment, for it is said of well-written or printed text, "The letters lie like pearls," an allusion to the uniformly equal setting and distribution.

For maps on a small scale, where many names must often occupy but a small space, the former law of proportions, where the minor of the height of letters is given as space, may be reiterated.

No names should be contracted or abbreviated, excepting those of objects for which custom has long ago substituted abbreviations, as are given on Table III.

PART III.

CONVENTIONAL SIGNS.

A.—CONVENTIONAL SIGNS OF THE ARMY AND NAVY.

These are taken from that eminent work, "Memorial Topographique et Militaire." The same characters are found in other similar works, proving that these signs are generally recognized. All signs are so simple as apparently to demand no further explanation. Wherever bodies of troops are described in colors, the national colors serve to distinguish them.

B.—CONVENTIONAL SIGNS OF TOPOGRAPHY.

Conventional signs represent objects which, in their orthographic projection, on account of minuteness of dimension, cannot be rendered distinct, and therefore have to be denoted in profile or ground-plan on a larger scale. These signatures indicate, as clearly as possible, the characteristic purport of such localities. All the signs exhibited in the first column on table VI. have an ethnographic signification, and typify the degree of culture of the locality represented. These are often of the utmost importance for military purposes: for instance, in reconnoitring and encamping, since the objects are mostly isolated and distant from towns or settlements; also in regard to obtaining forage, building material, implements, teams, and other means of transportation, etc. Objects built of stone are delineated on colored plans or maps in carmine, all others in Indian-ink.

Communications.—The transit of troops to and from great distances can be effected, on land only, by existing means of communication. The net-work of roads at the theatre of war is, therefore, the basis of all operations of an army.

Railroads and navigable streams, in the vicinity of an enemy,

are not always safe routes of communication for an army, since they can often be easily obstructed. The system of roads almost always, in a foreign country, of itself designates what portions of a territory are accessible to armies, and what direction is to be taken on invading the same. Avenues of communication must be previously explored with regard to their condition, because the movements of columns of from 50,000 to 60,000 men require a closer vigilance than ordinary travel. Roads are of various sorts; the condition of the ground, and the objects they subserve, define their peculiar construction. A large traffic with its adequate transportation establishes substantial highways, while a limited local trade builds a simple country road, a "field-track" or foot-path.

Railroads, the great invention of our century, by the application of the motive power of steam, do away generally with highways, especially in America. While in Europe channels of communication multiply the improvements in agriculture, in America the railway opens uncultured realms to the progress of civilization. In our own day, they follow in the track of armies, since the construction of temporary railroads is an easier enterprise than the building of substantial highways. For the designation of railroads, see tables V. and VI.

The oldest highways known were paved. Such were the roads built by the Romans, traces of which are still to be met with here and there. This class is best fitted for transportation at all seasons of the year; they are very durable, but occasion much wear and tear to vehicles; and, if once in a dilapidated state, become the worst of all. These roads occurring now but rarely, no special designation for them has been adopted, and they are included under the general classification of highways.

FIG. 1. *Highways* (*causeways*) *and post-roads* are conspicuous by their width and solid construction; they rest upon a substructure of large stones, interspersed with fragments of rock, with water-furrows or drains on either side.

Intersecting roads, leading from larger to smaller towns, and thus forming, as it were, a net-work of roads over a country, are called "cross-roads;" and, although of less width than highways, are generally quite as well constructed, and prove very serviceable military roads. The common roads in times of war claim the greatest amount of attention from military men, because they often form unfortunate impediments, and should be selected for the movements of columns only after a careful inspection.

FIGS. 4, 5, and 6. The condition of natural roads, such as *field-roads*, prairie-tracks, roads through woods, may be known with tolerable accuracy, after observing the effect of recent rains or other inclemencies of weather. Plank-roads and fascine-roads depend upon the care bestowed by the communities in whose vicinage they are situated.

Roads winding along the brinks of precipices may, perhaps, be properly termed *brink-roads*, or *mountain-paths* (Fig. 7), such as, in mountainous countries, are inaccessible to vehicles, and over which transportation of goods or material can be effected only by pack-horses or mules. Such roads pass across high ridges, and connect, by the shortest possible line of way, points which otherwise could be reached only by a circuitous route. They often ascend through steep ravines, or along the bed of mountain-torrents, so as to reach the saddle or pass of the ridge.

Foot-paths and by-ways (Fig. 8), leading across fields, meadows, and vineyards, through swamps and forests, and over mountains, are accessible to pedestrians only; their work is to shorten distances, and establish communications over obstacles which can be surmounted by man alone.

Hollow-ways, or defiles, are deeply-cut roads, or a narrow passage, as between hills. The former may be of extraordinary service, especially when inside a line of battle; they are particularly notorious for ambuscades.

Inclination of Roads.—The maximum of inclination in paved roads is 5 degrees, usually not more than 2½ degrees; and in common roads, there being much variance, it often attains, for short distances, an inclination of 7 degrees, or more. Roads very extended and considerably inclined are often provided with rests, as halting-places for vehicles. Turning-points in mountain-roads are dangerous, unless proportionably widened.

Wagon-track.—The width of the wagon-pass in every military reconnoissance, especially of natural roads, is of decided consequence, with a view to the passage of cannon and other equipage, as rain, inundation, and other accidents of climate, often render them impracticable for carriages at a different track.

Column-roads are those appointed and put into condition for temporary military purposes. They may follow a road, and then diverge therefrom, as circumstances may require; in order to be recognized as such, they are marked with stakes, on which bundles of straw or brushwood are fastened, at a distance of from 300

to 600 paces, or they are attached to trees or brushes on either side. In woods, the bark of trees is cut off at distances of from 50 to 100 paces; still another method is to whitewash the trunks of trees to a height of three or four feet, if the necessary articles can be readily procured.

Enclosures and fences of fields, meadows, gardens, etc.: Tables V. and VI., second column. "Fences": 1. Growing hedges; 2. Hurdle-work; 3. Boards; 4. Boards with stone supports; 5. Wooden rails; 6. Iron rails; 7. Stone walls without supports; 8. Stone walls with supports; 9. Mound bank of earth; 10. Enclosures of unhewn stone.

Passable Embankments.—1. Embankment of earth; 2. Embankment of fascines; 3. Walled in on one side; 4. Walled in throughout.

The character of these objects indicates the state of cultivation in a country. The nearer they are to large cities, the more solid appears their construction, and their relation to tactical operations entirely depends on the substantial style of the structures. From a military stand-point, they deserve every attention, especially when viewed as obstructions or means of communication, i. e., as places of a defensive or offensive character.

The proper appreciation of these structures belongs to the tactician; the office of the topographer is to describe and represent them in a manner leaving no doubt or uncertainty.

A careful and circumspect commander, on important reconnoitring expeditions, if the same be not under the direction of officers of the engineer corps, will therefore always order out an officer of the pioneer corps, in company with the topographer, to inquire into the true nature and conditions of such objects.

CONDITION OF THE GROUND.

FIG. 1. *Sandy ground*, in its various gradations, from coarse sand mixed with pebble, to the finest quicksand, never wholly retards the movements of troops—since, although offering more or less resistance, it has the advantage of an invariable condition in every kind of weather, and of greater convenience during the wet season.

FIG. 2. *Heath*, *prairies*, *steppes*, *deserts*, *llanos*—vast wastes of land elevated above the ocean—are level expanses of country, appearing as highlands or lowlands, according to the degree of

elevation. These plains, which only here and there have an inconsiderable elevation, relatively speaking, in whichever continent they may be situated, show peculiar features, while a sterile, monotonous aspect is common to them all. Here they are a promiscuous mass of sand and grassy soil; there, they are covered with heath, and are dusty during the hot season, full of fissures and cavities, and destitute of plants. When fertilized by the rains, they display for a time a most luxuriant vegetation; the continual pouring soon transforms them into far-expanding lakes: hence the mistaken accounts concerning bodies of water in the wilds of Africa and Australia, the true origin of which has been made known only recently by the explorations of scientific observers travelling through these regions. At other periods of the year, bereft of water, these sterile plains are the favorite haunts of tempests and wild animals, which man but little molests. Here civilization cannot gain a foothold, and nomadic tribes alone drone out a wretched existence.

FIG. 3. *Pastures, or commons*, are located in plains, or on the slopes of hills; and by the production of grasses, according to quality of soil, situation, or elevation, afford sustenance to cattle. In plains, they are evidence of little fertility, and generally denote a very hard or sandy soil, causing them to remain in a dry condition throughout the year. They thus constitute desirable ground for military encampments, and a most suitable field, if in front of an army, for offensive operations, especially to large masses of cavalry.

FIG. 4. *Turf* is the name of a damp, dark-brown, or black soil, mixed with waste clay and plants, and covered with a peculiar vegetation. The crust of turf varies in thickness from a few inches to thirty feet, and more; its density also varies much, and, like all soft soil, changes of season and weather affect it. The surface is generally overspread with a vegetable growth, consisting of sundry species of grass, heath, or moss, and, in places submerged by water, with marsh-plants, also of divers kinds, intermingling with brushwood and stunted pines. Pools are often found in turf-grounds of a dark-brownish water, such as dye-stuff, asphaltum, etc. Another product is the turf, which, lying directly adjacent to peat, appears as a vegetable substance of a brown hue, closely pressed together, and intimately interwoven as to its parts, or as a black, greasy mire.

The upper layer of turf shows distinctly its vegetable compo-

sition; at a great depth, even, this may be discerned, while the greasy, slimy turf, which proves the best combustible material, has lost all traces of a vegetable origin. There is also a supernatant turf, which, becoming disengaged from the bottom of the sea, is borne to the shore in pieces sometimes of several hundred cubic feet in bulk.

Turf is an object of great interest to natural science, as bones of animals and human skeletons—even bodies in clothes, well preserved through two centuries—have been found therein; also products of art, such as household utensils, and arms, and coins, from the days of the Romans. In the Netherlands province of Deuthe, not long ago, was discovered, under a ponderous layer of turf, the wooden bridge which Germanicus built when invading Germany. Traces of causeway reared by the Romans were found overgrown with turf. In France, and other countries, the bog also should be classed with turfy ground—a more solid, less elastic covering stretching over a body of water or swamp, of various thickness and coherency, usually too yielding to bear the weight of man. The bogs in the dry season are sometimes practicable for vehicles, though they only occasionally attain a degree of firmness that allows of walking on their surface. Bogs are often interspersed with swamps and turfy places, and, in their nature, either approach or are not unfrequently traversed by little streams. Clumps of alder-trees, willows, and other brush, are not rare, and, after proper drainage, bogs ordinarily become fruitful fields, known as marsh or bog land.

FIG. 5. *Marshes.*—It is characteristic of marshes to become dry in the hot season. The water constituting marshes is of a peculiar quality, muddy, absorbing a chemical composition of animal and vegetable matter, from which different gases are emitted, and which produce a luxuriant vegetation.

Smaller tracts of marsh are called morass; these are of a temporary character only, containing earth or clay, mixed with a deposition of water.

The reconnoitring of marshes and morasses requires great caution. Military history enumerates many disasters and decisive engagements in which marshy lands have become notorious.

Marshes are seen most frequently near rivers of low banks, where they are exposed to inundations in depressions, in the vicinity of springs or rivulets. Sometimes they are flourishing meadows, and their true character is found out by close observa-

tion only. When they are overgrown with cane and reed, some solid soil may be supposed to exist; their grass, however, emerging from a blue, reddish, or yellow water, indicates an impassable marsh. A careful examination should always ascertain the true nature of such a ground, since it may be the means of a surprise by the enemy, or the cause of an unnecessary roundabout movement of troops. An attempt to cross an impracticable marsh might endanger men and horses, especially artillery and wagons. Hence the following points should be investigated: 1. The origin of marshes and morasses; whether proceeding from springs of water or inundations; whether of a solid soil or the constant effect of streams low-banked. 2. The situation, extent, and surroundings; whether it is practicable to cross by horse, wagon, or artillery; by what circuitous route they may be avoided; at what season of the year, and in what weather, they are fordable; whether they dry up in summer; how deep they are, and the nature of their vegetation. 3. Whether they are traversed by embankments or wagon-roads; whether such might be constructed, or former ones repaired; what means of defence would be afforded; in how far the advance of troops would be facilitated or impeded.

FIG. 6. *A swamp* is ground covered with grass; though of a soft soil, yet not to an extent rendering it impassable for men, or even horses. In a military point of view, swamps are unfit for evolutions of bodies of troops in closed ranks, and admit only of skirmishing. Swamps may be termed wet meadows, which, through increasing softness of soil, become marshes. Dry meadows, by inundations or a rising of subterraneous water, may for a time become swamps. Sometimes swamps contain dry as well as marshy places; the latter generally are discriminated by the color of the grass, which appears darker and longer, also intermixed with "bog-plants." Drains and canals often traverse wet meadows.

FIG. 7. *Meadows.*—Of these there are three kinds: artificial meadows, where a higher productiveness is sought to be attained by artificial irrigation; "valley-meadows" and "mountain-meadows," the latter including, as a degree of cultivation, alpine meads.

Military science considers especially the hard or soft soil in meadows, whether they are accessible to cavalry and artillery or not. Mole-hills, wild clover, etc., can be seen from a distance, and indicate a hard soil and healthy vegetation. Cane, reed, rush, etc., are signs of a soft soil, and of unhealthy vegetation.

FIGS. 8, 9. *Fields* are either cultivated or fallow; if in grain, modern warfare will spare them as much as possible, and invade only in cases of dire necessity; for often the preservation of an army, and the success of an expedition, depend on the products of the fields, which, for this reason, are objects of special attention to the soldier. A particular designation of cereals growing on fields may be made only on large maps, and even then no further than to distinguish bread-stuffs from other plants.

FIG. 10. *Olive-yards and vineyards* are but rarely met with in a level country; generally we find them on the slope of hills, or laid out in terraces on rocky eminences. The manner in which the vine is planted gives it a strong defensive character, and is notorious for obstinate contests.

FIG. 11. *Hop-yards*, if the vines are raised on high poles, become an essential means of protection, behind which evolutions of troops can go on unobserved.

FIGS. 12, 13. *Orchards and vegetable-gardens* are generally close to dwellings, or on the outskirts of towns, and are important to military observation chiefly by their enclosures.

FIG. 14. *Rice-fields* are surrounded by high embankments, serving as aqueducts to submerge the fields.

FIG. 15. *Bushes and trees* find a place in topographical maps when they are particularly conspicuous objects in a landscape. Bushes are small thickets or woods, consisting of trees and smaller shrubbery, surrounded by fields, meadows, etc., unconnected with larger forests. They are accessible to skirmishers.

Undergrowth, being often dense and intertwined, like hedges, is ordinarily inaccessible.

Woods are of primary importance in a military view. The soldier welcomes the forest as a dear friend, affording him refreshment and protection. But what is a protection to the one, becomes an obstacle to the other, and a fight for the possession of a wood is always distinguished by the most extreme severity. The nature of woods determines their military usefulness. Consisting of much undergrowth, or of young saplings when scattered or thickly grown, or forming impenetrable forests, as in tropical climates is generally the case, the condition of their soil, if dry or marshy, characterizes their adaptability to military purposes, which is thereby determined.

In woods of leaf-bearing trees, brushwood forms the so-called undergrowth; this, especially when consisting of willow, poplar,

beech, etc., may be used for fascines, musket-baskets, and the like, of such importance in a siege.

Young woods contain low and slender trees, three to six inches in thickness, and attaining a height of even twenty feet. They are thickly grown, not cleared, and are accessible to troops only by roads cut on purpose; frequently deep ditches, traversing such woods, form serious obstacles. To the soldier, it is of essential importance whether a wood is sparse or close; sparse, when the trees are far apart, so that a horseman can pass through without much difficulty, or even a vehicle, as is especially the case with pine-wood; close, when the trees stand near together, surrounded by bushes and saplings, traversed by foot-paths only, rendering any movement of troops or vehicles impossible.

The steep declivities of mountains are generally covered with wood. The true homestead of forests, however, is on level highlands and lowlands, where extensive woods are found, natural or artificial.

The *covert* ("Waldmantel" in German) of a forest is the surrounding space, of about 500 feet in width, in which the undergrowth is left, intended as a shelter against wind and tempest for the trees inside, until the latter attain a certain strength. Where this precaution had not been taken with pine-woods, a strong gale not unfrequently has broken off or uprooted the trees reared for seed. For this reason military reconnoissances should always penetrate some distance into a wood.

Dry and sandy countries generally bring forth fir-trees; loamy soils produce oaks; unctuous soils, ash-trees; or, indurate and rough soils, beeches; sour soils, maples; wet soils, poplars, willows, and alder-trees; and on high, rocky and sandy ground, are found the pine and similar trees. Woods of alder-trees are often an indication of marshy ground. On the summit of mountains and near the line of snow, pine-trees have a dwarfish appearance, and often dwindle into creeping plants. On the borders of a lake (e. g., Wildensee in Würtemberg), the so-called trailing-fir ("Legforche" in German) grows up to 10 or 15 feet in height, and then inclines downward, forming by its branches—rarely over 8 or 10 inches thick—a sort of natural bridge over the marshy environs of the lake.

Topographical description, as well as designation of woods on drawings, admits of three different classes or characteristics: *leafed-woods*, *pine-woods*, and, in tropical regions, *palm-woods*.

Distinctions between underbrush and high-woods are not considered in topographical drawings, but are so in descriptions, as well with regard to the condition as to the age of a forest; thus a forest never touched by the axe of civilization, will be called a *primeval forest*, provided it is really of long standing; or a *huge forest*, when consisting of tall trees, indicating a firm soil. Change of form, in pine-woods especially, should be noted in descriptions, whether of fir or pine trees, since their conditions are, from a military point of view, as different as + and — for tactical purposes. Both of these kinds of trees, at an early stage, are full of boughs, and form a pyramidical bush, and when grouped closely together become a thicket, impenetrable to man, except after employing the axe. When of middle size, and in full height, the conditions are entirely changed; the trunks, to a certain extent, are denuded of branches—those of solitary trees only are occasionally an exception; then, the forest becomes perfectly accessible to infantry, and has the advantage of affording a larger sphere of vision, since the trunks, though tall, are yet slender.

Trees from 10 to 15 feet in height, or those which in thickness or magnitude are mere shrubs, are called low woods—small woods; or, when they are regularly planted, nurseries and plantations.

Palm-woods.—On both sides of the equator are still to be found primeval forests of palm-trees. No similar vegetation, produced by the warmth of the sun and the dampness of the soil, exists any where out of the tropics. The ground between the mighty trees of a palm-wood is covered with a thick shrubbery, through which the axe alone can clear a passage. Hence, such regions are little known to man, beyond the vicinity of the navigable rivers. Even Indian paths through palm-woods require the constant use of the "manchetta" in the hand of a native familiar with the route.

Mangroves consist of trees and shrubs indigenous to the tropics, and found on the sea-coasts. They abound more particularly about the mouths of rivers, where they grow in the mud, and form a dense thicket, creeping downward, even to the strand, as far as low water-mark. Most of the species send down roots from their twigs, and thus rapidly extend over large spaces.

A recapitulation of the results obtained for the military examination of woods presents the following points:

1. Situation—in regard to the surrounding conditions of the terrene; i. e., if the forest is in a bottom-land—on the slope or summit of mountains—or surrounded by or near other woods.

2. Size—length and width.

3. Interior conditions—one or several kinds of trees; sparse or thick; whether containing cleared ground, farms, villages, etc.

4. Condition of the girdle of the forest; its exact outlines.

5. Accessibility; traversing roads, and the points they connect at; what paths there are through the forest (see Fig. 17, Tables V. and VI.).

6. Condition of the soil—hard or soft; marshy or dry; containing ponds or lakes; ditches or embankments; cavities caused by inundation or rain, or the uprooting of trees.

CONVENTIONAL SIGNS OF HYDROGRAPHY.

Hydrography embraces a description of the various forms assumed by water. These forms are so various, and bear such a numerical preponderance to all others represented on the globe, that their investigation constitutes a special science among all maritime nations.

Waters of the Sea.—The undulated surface of the globe may be supposed to have been deluged with water, which, filling all cavities to a certain extent, gave it a spheroidal form. The boundary between sea and land is called a coast or shore, the first name being generally applied to elevated, the second to low ground.

The sea is divided into oceans and seas; inlets of the sea into the land are called bays, gulfs, creeks, fiords, and, when long and narrow, channels, or arms; small passes connecting oceans are designated as straits. Projections of a coast into the sea are peninsulas, isthmuses, capes, etc.

Vertical measurements on land proceed from the level of the sea, and are designated as heights; measurement below the surface of the sea, as depths of the water.

The constant motion of the sea, together with the effect of gravity, preserves a uniform level of the waters, and the efflux on one side is replaced by influx on the other. The only change in the level of the sea is a periodical rising and falling at the coasts, called tides, consisting of ebb and flow, high and low tides. The causes of this phenomenon belong to the sphere of physics, but the results of observation are noted in hydrography.

Ocean-currents.—The struggle of the masses of water in reestablishing a spheroidal equilibrium produces currents in the sea, and natural philosophy teaches that the attraction of the sun, and, still more, that of the moon, keeps the waters in constant motion.

If the earth were without land, these motions would be very simple; proceeding from the poles, they would gradually take a westerly direction, following finally the line of the equator; but the configuration of the land, and also of the bottom of the sea, gives to the equatorial current its well-known direction. Other ocean-currents originate in local formations of land, from the influx of other seas, or of large continental rivers, the course of which can often be traced very far into the sea. Still another cause of ocean-currents is found in the motion of atmospheric winds.

Topography inquires into the "*velocity of water-currents.*" With rivers, this does not present much difficulty; but, on the sea, where no stationary point of coast offers a measure upon which to reduce the motion of the waters, it becomes necessary to employ other standards. The first object indicating the direction of a current is the parallel direction of sea-plants floating on its surface. A second starting-point is in the deviation of vessels from their course, and the direction of bodies swimming on the water. Empty bottles, containing a note, with date, time, and place, when dropped by a vessel, have been carried away by currents, and, when picked up by another ship, have given information regarding the direction and rapidity of a current.

The average velocity of currents known at present is about thirty sea-miles per day. It varies greatly according to the width of the current. The Gulf-Stream, near Florida, has a velocity of five miles per hour, while it moves at the rate of one mile only on attaining a width of two hundred and fifty miles in the Atlantic ocean. The velocity of other ocean-currents has been ascertained, and varies from 2 to 7.9 feet per second. Three to four feet per second are assumed as the velocity of rivers. In Alpine rivers, it rises to 11.6 feet, so that ocean-currents have as much velocity as rivers.

Bottom and Depth of the Sea.—Exploring the depth of the sea gives information, also, of the condition of its bottom. Fossil shells, living on the bottom of the sea, must receive their nourishment, and the substance for the formation of their cells, from the currents of the water; hence, the sea in which they live and grow cannot be at rest. The motion of the waves, however, does not extend beyond a certain depth; and, since it follows that new supplies of water can reach the fossil shells on the ground only, by currents descending so deep, submarine currents, therefore, must exist.

"*Soundings*" by naval authorities are not confined to a fixed distance from the coast, but are regulated by the configuration of

the bottom of the sea, in order to investigate the feasibility of coast navigation. In the United States, Prof. Bache extended soundings from the eastern coast of the Atlantic to the Gulf-Stream, and thus established a geographical line of demarcation. The inclinations of the bottom, from the shore toward the sea, are, of course, of great diversity, and are changeable, according to the active co-operation of a current with the process of erosion. For this reason, no definite rules for the elevation of the bottom of the sea can be given. By erosion, all that the waters bear away from the highest and lowest points of continents and islands is borne into the sea. Surf, or breakers, wear away the steep shores; and often large masses of rock, detached by the waves, are crushed and dissolved by the breakers. Whatever water can carry, floats away with the currents, and is deposited in calmer seas. The velocity of large rivers, and the movement of floating objects, as a rule, decrease when they approach their outlet into the sea. The deltas in the sea and the sand-bars show how far objects can be floated. Since the water of rivers is of less specific gravity than that of the sea, its final effluence into the latter must end in a gliding over its surface. When a turbid river enters a tranquil sea, its current can be followed for many miles, and then easily-floating bodies are deposited; but sand and bowlders are not conveyed so far. Wherever detritus is precipitated, far from the mouth of rivers or the action of breakers, it must have been transported thither by the erosion at the bottom of the sea, by submarine currents, or by icebergs, in a manner similar to that which has been observed as occurring in glaciers.

From the rivers, we learn what takes place in the depth of the sea. Where smaller rivers unite with larger streams, sand-banks are formed, visible at low water, and partly washed away by the eddies. Tributary rivers are often forced to alter their course if more detritus is added than the waters can remove. An interruption of the flow of water promotes deposition, as is proved by the wears erected in rivers for the protection of the banks, near which substances carried by the current are deposited. When such deposits on the bottom of the sea are augmented by combining currents, the same result must follow as is seen at the wears of a river: a submarine mountain grows in height and width, and shallows and sand-banks are formed. If the detritus consists of bowlders, the bank thus fashioned is called a home-ledge; if of shells or oysters, a shell-ledge, or bank; if of corals, a coral-bank.

Reefs are a line of sand or coral banks near the coast. Coral islands, banks, and reefs, are the work of small infusoria, frail and brilliant zoophytes. When one of these structures reaches the surface of the water, the coral insect dies. All elevated coral reefs have been upreared by changes at the bottom of the sea. The shape of coral islands also depends on the condition of the bottom, some being nearly spherical, others in the form of a horseshoe; others, again, of an oval or rectangular figure, measuring thirty or more English miles in length, by five miles in width, while many have an area of only six thousand by three hundred feet. In close proximity to these islands, the depth of the sea is generally very considerable, and frequently the sounding-lead can find no bottom. A peculiar feature of these coral islands is, that they embosom lagoons or lakes, large and small, from a few to several hundred feet in depth. Where these lagoons do not exist, they are supposed to have been filled up by the structures of corals or other material cast up by the sea.

The grandest of reefs are the so-called "Barrier-reefs," which stretch parallel with the coast, and are distant from thirty to seventy miles. Where the coast is shallow, close to it, or at far distances, "fringing reefs," either subaqueous or protruding above the surface of the water, are found.

The environs of the sea, i. e., the coasts, are low or elevated, often steep and mountainous, or sandy beach.

A beach—the work of waves and currents—is that portion of the sea-coast overrun by high, and left bare by low tides. It is composed of pebbles, sand, and other coarse substances, washed on by the waves from the bottom of the sea, and piled up without any regularity. In the course of time, carbonate of lime and oxide of iron cement the sand and stony parts of the beach into sandstone and other conglomerates.

If certain local currents are famous for exposing smaller vessels to danger, the before-described shallows are still more perilous to the navigator; but more formidable than these are submerged reefs and coral-banks, which sometimes spring up from an immense depth. Hence the great importance of soundings, and the preparation of maps and prepared lists of reported dangers * of the oceans,

* An excellent work of this kind is compiled by E. Knorr, and published by the Bureau of Navigation, Washington, 1866, under the title of "A List of the Reported Dangers to Navigation in the Pacific Ocean, whose Positions are doubtful, or not found on the Charts in General Use."

from which the mariner, even in the obscurity of mist or night, can verify the position of his vessel, as ascertained by calculation, and select the right course.

The line of high water is fixed as the proper coast-line: the limit of low tide is called low-water mark. In order to gain a correct view of the navigable coast, the level is taken from the low-water mark, and represented by three curves, of six, twelve, and eighteen feet. All soundings between these lines are given in feet, but, from eighteen feet downward, are designated in fathoms.

Within the line of demarcation of eighteen feet, the state of the bottom of the sea is expressed by conventional signs; beyond it, however, by abbreviations (see Abbreviations, Table III.).

Concerning the designation of rocks above or below the water, their exact or approximate position, their reported but not confirmed existence, see Table VIII., first column.

Inland Waters.—The undulations of the surface, forming more or less water-furrows and rivulets, which, taking their course, sometimes accumulate in depressions, without any further visible effluxion. This gathering of water rises to a certain height, becomes standing water, and, according to its peculiarities, is called by various names: a puddle, when occasioned by rains; dead water, when left from an inundation. If lodged artificially, it is called a pond, and more extended standing waters are called lakes.

When the water of a spring finds no outlet, and collects in large quantities in a depression, it does not remain pure, but is soon filled with many organic substances, especially waste matter of plants, and converted into a morass, or swamp.

Lakes are denominated, according to their situation, as mountain-lakes, prairie-lakes, periodical lakes, etc.; if they are only an abnormal widening of a stream, they are called river-lakes.

All these water-basins will disappear in time, unless repeated revolutions of the earth create new ones. After a river enters a lake, its course may be traced for some distance; but, during its progress, it gradually loses a portion of its velocity—from being diffused over a large mass of water—and it can no longer propel sand, stones, etc., in its course; its muddy stream is changed into pure water, and spares these countries it traverses of all further detritus. Lakes, or even great widenings of the river-beds, are of great importance to the country, since, after a sudden flood, the accumulated water is distributed over the entire lake, causing no inundation on its departure.

Creeks, Rivers, and Streams.—Springs and glaciers give rise to creeks and rivers, the beginnings of which are generally quite insignificant. Several creeks uniting form a river, though some issue from the rock as rivers, as the Sorgue, in Illyria, which is navigable from its source.

The zone of land dividing two basins of rivers may be termed the fountain-district; and the dividing ridge, whence the water flows in opposite directions, is called a water-shed. The larger a river, all conditions being otherwise equal, the larger is its basin. In general, the extent of its basin, not the high situation of its source, determines the size of a stream. It is not necessary to look for the sources of large streams on the highest point; considerable heights are often of little moment to a stream, while the water-shed of many large rivers is but little elevated.

Since the water-shed of two rivers must be higher than either, and sources are generally found in the mountains, it is near the summit the former is first looked for; but a water-shed may be a moderately inclined plain, and it sometimes disappears altogether, when one valley-system is connected with another. In the first of these cases, the so-called portages are formed; the latter give rise to bifurcations, or forks. Portages derive their name from the practice of conveying boats, etc., from one fluvial district into another, and they are especially favorable to the formation of canals. They are often to be found in European and Asiatic Russia. North America possesses a very important portage between the river-plains of the St. Lawrence and the Mississippi.

Velocity of River-water.—The bed of rivers forms an inclined plane, from the source to the sea, and one is therefore led to expect a considerable velocity in the vicinity of the latter, as here the water for so long a period has fallen; for, with an inclination of one degree, after a fall of two miles, that velocity should attain to eighteen hundred feet per second. Now, on comparing this result with the actual fact, we find forthwith that this enormous rapidity is far from being attained, as, on an average, it only amounts to three or four feet. The examination of a short portion of a stream, on which the inclination does not perceptibly change, shows the movement of the water to be constant; thus, as a distinctive feature of the motion, the accelerated rapidity slackens. Something must here hinder the water from falling thus rapidly, and the obstacle is to be found in the two following causes:

When bends occur in a river-bed, the water impinges on prom-

inent objects, and encounters a resistance it endeavors to overcome, which it really does; but, in doing so, it loses somewhat of its momentum, because, in its passage, it has had to flow over such intruding objects.

The second impeding cause is the tendency of water to adhere to all objects with which it comes in contact; i. e., to wet them. Suppose a body of water, from its bed to its surface, divided into thin horizontal layers. The lower half meets the soil, and thereby completely loses its motion; now, as the separate portions of water take hold not only of solid objects, but of themselves, as is seen in the formation of drops, so the lower layer but one will seek to adhere to the lowest, the third to the second, and so on. Thus is lost, at each successive adhesion, not all, but nevertheless a percentage, of its initial motion, and the upper layers will therefore always proceed slower than those immediately below, as is the case with glaciers. At the surface itself, the motion is again slower, because the adhesiveness of the water to the atmosphere produces similar phenomena as it did to the soil. Here the upper layers retard those immediately below, and the greatest velocity is to be found near the surface. Ordinarily, the action of the atmosphere is weaker than that of the earth, but it can become considerable, on a violent wind raging up-stream. Should the water flow rapidly, it would thereby be very much retarded; but, if the original flow is sluggish, the current can be brought to a stand-still. During this check, the upper waves of water receive a back pressure, the result of which is known under the name of storm-flood, and which is dreaded for the destruction it occasions.

Upper, Middle, and Lower Flow of Streams.—In following a stream from its source to its mouth, great changes are observed in its apppearance as well as in its whole condition; for, not only is the size varied with the ever-increasing distance from the source, but also its hypsometrical position, which C. von Ritter has very beautifully characterized by bringing the course of streams into three parts, which he has designated by the names upper, middle, and lower flow of streams, and who considers those streams alone perfect which are capable of possessing this threefold characteristic division.

The upper flow of rivers is distinguished by the greater inclination of the bed. The banks are steep, and the tributaries of the stream rush down as torrents, with great power and velocity, especially after a previous rain-spell. No exact space can here be

maintained for its bed, but the river forces its way through deep gaps; still, it cannot give to the region a new aspect, even if it has the power to enlarge an already-existing cleft, or to cut deeper. The bed of the river depends entirely upon the form of the solid bottom; it proceeds in a straight line, or twists into acute angles. The mountain-torrent is wild, raging, and rushing, hissing when it hurtles against an obstacle; or, roaring, it dashes itself headlong into an abyss; or, when its fall is too precipitous, dissolving into spray under pressure of the air. Throughout its course it shows a tendency to remove all unevenness in its way, and to open a free passage for its waters. The greater the hinderance to its progress, the more its velocity and power are increased.

The transition into the middle course is often formed by one of those grand phenomena of Nature, the cataract or rapids, in which the rock makes a final struggle for superiority against the stream.

The difference in height between the beginning and the end of the upper course of a river is often very considerable. The German Alps, at their northern extremity, reach an average height of from 6,000 to 8,000 feet, while rivers start from them at a height of 2,000 feet; the distance representing this difference of altitude is greater on the opposite side of the mountains. Rivers in the Andes, which are 20,000 feet high, according to Humboldt, issue from the mountains at a height not exceeding 2,000 feet.

The current of the river is not always so impetuous as might be inferred; for sometimes a wide space is open to receive it, and within the mountains it pursues a quiet course through a beautiful valley, the latter offering a not unfrequently broad recess, wherein it expands into a calm and pleasant lake. The water, after filling such a basin, will rise until it finds an outlet in an opposite direction. It is in this way that the depth of the sea is regulated. All bowlders, and other matters transported by the stream, will be deposited in such a lake, and a clear stream pours forth again, whence results the gradual filling up of the lake, and the formation of a fruitful valley, the soil of which consists of alluvial deposits. Where the lake, or the vale formed within it, reaches the lowest verge of the surrounding wall, the water plunges over, and appears in a series of cataracts or rapids, until a second basin is found, which it fills in like manner.

When the river has once entered its middle course, the mountains, becoming less steep, recede from either side, the lofty ones

are left behind, and ridges of hills take their place; with an unencumbered space ahead, it seeks a definite way, and valleys surround the river-bed. In its upper course, the movement is regulated by the formation of the rocks; in its middle course, where occasionally obstacles still occur that cannot be surmounted, it turns aside, and resumes the former direction, as the condition of the ground permits. This causes the appearance of horseshoe bends, which are the distinctive feature of the middle course in contradistinction to the upper. The inclination of the bed, measured before by thousands of feet, is now considerably diminished.

As in the transition from the upper into the middle course, so also that from the latter into the lower course, is often marked by sudden changes, though the altitude is no longer sufficient, for there, cataracts, rapids, whirlpools, and the like, interpose the remains of former larger falls, while the country before them is the place of former lakes.

In the upper course the configuration of the ground controlled the direction of the stream, and in the middle course it was governed unitedly by the river and surface over which it passed; in its lower portion, however, the river is master of its course. The elevated banks of the middle course having now disappeared, the water winds along, so to say, *ad libitum*, on a level, and alters its course only from impediments of its own construction, such as bars, etc., from which it either turns aside to heap up other accumulations, or, by overflowing, carries them away to other places. Finally, the river generally, toward the end of its course, diverges into several branches, forming islands and sand-bars, which it again destroys; these characterize the lower portion of the stream.

The river-bed retains but little of its fall or inclination; no mountains, cataracts, or rapids, mark its lower course, but the bowlders it carries assume vaster proportions, and often elevate a large tract of country, until the stream is forced to forsake its former bed, and to select a new channel. To avoid the danger of inundating the surrounding lands, dikes, or embankments, are erected to keep the stream in its channel; these, from time to time, must be raised higher, until at last not only the level of the water, but even the bottom of the stream, becomes more elevated than the adjacent land, as is the case with the rivers Po, Rhone, and Rhine.

The elevation of the river brings about also a corresponding elevation of the bottom of the sea, as all motion from the river

there emptying ceases, and floating substances are forced to sink. Hence the mouth of a river is generally in shallow water, whether it be in a lake or in the ocean. If the deposits of sand fill up the mouth, the water seeks a way to either side, and thus forms one or more islands, which, from a similarity of shape to the Greek letter Δ, are called Deltas. However, the alterations of the river's course do not end as yet; the various branches are gradually blocked up with sand; other ramifications of water stretch out like forks, washing away one delta to raise up another, and causing a recession of the sea. The formation of deltas enlarges the land, diminishes the fall or velocity of the river, and favors this deposition of sand and rubbish in its course.

The same appearances as those offered by rivers terminating in the ocean are seen when they enter a lake. But the formation of deltas is possible only when the mouth of the stream is protected against the pressure of tide; for, though the rising of the tide effects a like rising of the stream, which then deposits its bowlder, the receding tide and the recoiling sea restore the discharge of water from the river, increase its velocity, and remove all deposits, This not only prevents the formation of deltas, but brings about an extension of the mouth of the river, known as a negative delta, or æstuarium; æstuariums are found in the Elbe, the La Plata, the St. Lawrence, etc. Deltas are generally formed in inland seas, or in calmer bays.

Where a river directly flows into the ocean, it often, at little distance from its mouth, forms a bank, which is heightened by the waves of the ocean, that continually deposit sand thereon. Thus is formed a connection between the deposits of the river and dunes, which is continued in a long, narrow track. A stream of little power is thereby turned aside, and the sand-bank follows it in all directions, and finally connects itself with the land. Then the river gradually fills up the intervening lagoon, and thus makes an addition to the land. Such formations are called polders on the sea-shore, and they appear only in seas not exposed to frequent and violent storms.

NATURAL AND ARTIFICIAL PASSAGES OVER WATER.—*See* PLATE VIII.

A ford is a shallow place, reaching from one to the other bank of a stream, if the ground is solid enough to permit the passage of animals and vehicles. Frequently fords can be recognized by a curling and more active motion of the water than at deeper places,

the cause of which appears to be, that the smaller volume of water cannot so easily overcome the unevenness of a ground much nearer to the surface, and thereby suffers constant interruptions. Fords generally occur where a river is widened, because the decreased motion of the water gives cause for deposits by which the bottom of the stream is elevated.

Ferries, Bridges, and other Superstructures.—Water and wood are the first conditions to the settlement of any country, and rivers may be justly designated the arteries of civilization. The highest interests of nations are attached to the rivers of a country; no other element offers such a multiplicity of interests. For the purpose of this work, a further description of them is not demanded; and, therefore, it offers only the topographical designations in Tables VII. and VIII., the importance of which the history of the culture, science, architecture, and art of nations, as well as of military science, has sufficiently demonstrated.

CONVENTIONAL SIGNS OF HABITATIONS—PLATES IX. AND X.

Under the general designation of habitations, the topographer includes all dwellings of man, from the hut to the populous city. However great the distinctions between these extremes may be, their importance in regard to tactics is not in proportion to their extent. A solitary structure, a castle or farm-house, standing before a line of battle, may be of momentous decision in an engagement.

Castles and fortified towers, ancient convents, erected during the middle ages, strengthened by nature or art, surrounded by strong walls and water, steep mountain or rock, and thus secured against the attack of an enemy, constitute excellent posts for temporary defence, especially when situated on an eminence, or in a mountain-pass. Often the retreat of an army, or the conveyance of provisions and ammunition, has been furthered or protected by such mountain-forts, and they always offer an excellent *coigne of vantage* for outposts, and for observing the enemy's position. Old field-works from a former campaign, and all structures of solid stone or brick, such as churches, graveyards, etc., when in a solitary and in a military point favorable situation, have served at all times as strongholds for troops attacked on the march, into which they threw themselves for effective resistance. The defence of the church-yard of Hochkirch, in 1757, of Leuthen, and St. Lucia near Verona, are well-known illustrations.

A few houses not far apart are called a hamlet, or settlement. A community is called a village, when it has no church or parsonage; but a village with a parsonage is styled a parish.

The natural disposition and nature of villages depend chiefly upon the region in which they lie. Villages in a flat region are generally connected and surrounded by hedges or fences, and laid out in streets which lead into field-paths, if in the vicinity of country roads, built on both sides, and sometimes from three to five miles long. In mountainous districts, houses generally skirt the valleys, but are also often scattered for miles without any particular connection, partly in the valley, partly on the declivities; and such communities are often designated as upper, middle, or lower villages.

Communities which possess a market are called small market-towns.

Communities in which not only agriculturists, but also artisans of every description had settled, were, by means of certain privileges, raised to the dignity of cities. Warlike inroads, especially those of the Avars and the Hungarians, with their horse-squadrons, compelled the inhabitants to surround their settlements with wall and ditch, which were not only filled up by protection-seeking country people, but also by craftsmen, artisans, the learned and the noble, and thereby were gaining more and more importance, until violence and onslaught called the strongly-fortified cities of the empire into being, which became the seat of arts and sciences, as formerly the environed monasteries had been.

All the wall-enclosed cities of Europe belong, as already said, to the middle ages, and very many of them cherish with pride the reminiscences of their walls and towers, which bear testimony to the might and courage they exhibited in their conflict for independence against the usurpations of feudalism, as also against more powerful armies; but these defences would to-day bring ruin and misery over a city, if behind those ramparts the idea of a serious resistance were entertained. With the improvements in artillery, other means of defence of a more formidable nature were necessitated, in order to secure the store-houses and magazines of the nation, and thus fortresses arose; and in the course of time, as these came in vogue, it was deemed advisable to encircle even the frontiers of the empire with fortifications—which, however, history soon proved to be nothing but a useless and scattered waste of strength.

With regard to the present fate of cities in case of an invasion, General C. von Decker says: "When, in the course of war, large cities, succumbing to the power of arms, fall into our hands, by a skilful employment of their resources immense advantages may be drawn from their retention. A large city is to be considered as the centre, in a greater or lesser degree, of the national resources of the enemy, and as the seat of various and important resources for warfare; and therefore the possession offers to us the double advantage, not only to avail ourselves of such resources, but to withhold them from the use of the enemy. While thus the burning down of the enemy's cities was the worst that could be done, the gain at one's command, by their preservation, is the thorough and methodical use of their strength and resources. Small communities, or isolated farm-houses, the sad fate of which is to come within reach of the line of battle, fare badly, their position rendering them instrumental to military purpose; nothing but burning ruins attest their site, when the thunder-bolts of war have passed over them."

As to solitary buildings, groups of houses, small settlements, etc., military requirements consider: 1. Their position or situation; 2. Whether exposed, or surrounded by enclosures, and the character of the latter; 3. What communications they control; 4. For the assailed, all these points serve as items, when considered with regard to danger from without, to which are added the means of security from within; danger from conflagration, for instance, destruction by fire being their usual lot, when not obviated to the utmost, or caused on the retreat, when they are not held as forlorn posts to be retained at all hazards.

As to larger communities, in addition to the above considerations, the surrounding terrene is of the greatest importance to the tactician, if it be of a commanding nature, or what is the character of the construction and situation of the streets.

In the case of fortified places, it can be said that the surrounding terrene becomes more and more important, foot by foot, the nearer it comes within range. If they cannot be taken by surprise, and siege in form has to be resorted to, then it must be preceded by the most minute survey of their capabilities, for both attack and defence.

We are now in the domain of the engineer, to whom, in recent times, the sieges of Sebastopol, Vicksburg, and Petersburg, offer rich material for the use to be made of every foot of ground.

Concerning the Disposition and Laying-out of Cities.—We are taught, in our school-days even, that cities are the seat of culture, and that the multitude of cities announce the state of civilization and prosperity of a country; that is to say, in other words, civilization and prosperity can only thrive and increase through the centralization of human powers.

From the hoary record of mankind down to the present day, the prosperity and thriving of cities has been constantly dependent upon their geographical situation, by means of which their characteristic stamp has received its impress; i. e., they became either the seat of government—and it was in this, generally, that the strategical position was of decisive influence—or commercial cities, and became so in consequence of their facilities for communication; or, again, they were seats of industry, and here the immediate conditions of the soil were the determining motive; whereas, agriculturists, by all odds the majority and power of a country, alone remained scattered, or were only concentrated into small boroughs—thus, in the general forethought for the soil, that for man had been forgotten.

To be just, we must admit that little is to be credited either to the wisdom of governments or to the prudence of mankind, as far as the happy selection and disposition of cities are concerned, but that their prosperity and increase are to be set down to the sport of change and of emergencies. That there are exceptions to this dictum, as well in ancient as in modern times, we know, and they are easily enumerated; but that a mania for the slapdash laying-out of cities, or, if you like it better, a regular city-lots swindle, should have eventuated in favor of mere fancy spots, however obscure, is to be ascribed to the success of so many offshoots from the first settlers in America, set in motion and fostered by the emigration of peoples to her shores.

But, when we view this new historical spectacle, which is evolving itself here before our eyes, we find that a bearing the very reverse presents itself. Here, an immigration from cultivated and thriving but overpopulated countries, discharges itself upon a soil hitherto untilled, dislodging the domiciled nomadic savages; whereas, in Europe, wandering cohorts swarmed over thriving states, the indwellers of which they expelled, annihilated, or reduced to slavery. Unfortunately, in both methods of taking possession, the same means were applied, and have had the same result, viz., the appropriation of the soil by fire and sword, and

the attendant consequences, havoc and disease to land and life. The combats and exertions, the sufferings and hardships of the first settlers are well known, and are applicable in the present day to the common events of the far West. It is, therefore, an absurdity to dignify this method of appropriating and settling the Territories with the name of "*march of civilization.*"

The fault does not lie with the pioneers. They, when their generally-scattered and self-sustaining strength is kept in view, had to shift as best they could. The fault weighs heavily on the shoulders of those who are called to the councils of the nation, and in whose hands their guidance is intrusted. It is just that amount of discernment necessary to discover the proper means for remedying this evil, and of putting them into operation, which is wanting.

The pacification of the Indians, it was thought, might be brought about by a system of military posts; but, down to the present hour, the situation has not been improved. The child of Nature can only be overmastered by dint of power—and his subjugation can only be secured by assimilation, and not by tributes and renewed treaties. The subduing of the Indian tribes, and even their assimilation, is but the least part of the great problem of a veritable, energetic civilization, which can only come into effect when the entire immigration is changed into a thoroughly organized colonization, carried on in legions; i. e., by means of a systematic procedure, bearing upon the cultivation and situation of such colonies, not only for mutual protection, but much more for the prosperity and well-being of the domestic hearth on the one side, and for a blissful training up of succeeding generations on the other.

As a matter of fact, the solution of this problem is not only a military question, but one in which all means of progress are involved. In this organization problem, the topographer participates in the highest degree, because it is in his hands that we should place it, when a selection of the points for the cultivation of future regions is on the *tapis*. Thus his profession is called into play to its utmost scope. Of course he cannot solely examine the investigations likely to accrue, consequently the agriculturist and geologist must with him, conjointly and simultaneously, reconnoitre the ground, and afterward harmoniously prepare the necessary plans.

It is only thus that the requisite considerations of soil and cli-

mate can be taken into proper account. The procedure pursued hitherto is synonymous with a complete ignoring of all practical and scientific experience, the topographer having been looked upon as a mere geometrician.

The suggestions put forth on these important questions, applicable as they are to the topographer, sufficiently demonstrate that the profession of a topographer is not confined to the mere art of surveying, but that he should possess the ability to inquire into the physical properties of the soil, which necessarily can only be attained by the study of natural sciences, or that at least he should be acquainted with those branches which are paramount in their bearings on surface topographically surveyed, in order to prescribe the following subjects:

1. Concerning climatography, with regard to the temperature of the seasons, classified as Medium, Minima, and Maxima: amount and time of atmospherical discharges, rain, snow, etc.; seed, blossom, and harvest-time.

2. Concerning hydrography, in relation to the river-region: ebb and flow, breadth and depth, navigability, velocity; height of water in spring, summer, autumn, and winter; time of inundations, their duration and height; nature of deposits, whether organic or inorganic; amount of yearly deposit; earliest and latest freezing of rivers; remarks upon the condition and cause of swamps; character of springs and drinkable waters.

3. Concerning the hypsometrical proportions of the country, the exact knowledge of altitudes is important in many respects, such as for climatography; orography; means of communications by land and water; construction of canals, and drainage.

4. Anthropological notices: religion; ethnographical relations; manners and customs; prevailing diseases, and their origin; means of subsistence; habiliments.

The geological considerations, as well as the character of plants, and their propagation, and, in addition, the zoological relations—problems for the mastery of which the whole capacities of a man are called forth, and with which the topographer cannot be burdened—are nevertheless of the greatest moment, and have obtained well-merited favor on exploring expeditions.

When the topographers, endowed with such knowledge, investigate territories, a prudent management of the organized frontiers, based upon such material, preceding the colonization, conflicts with the Indians would soon cease, and the government would no

longer need to throw millions, as it were, into the sea, such a pecuniary sacrifice serving only to enrich certain contractors.

Colonies would flourish; families being freed from all fear, the education of their children would become obligatory, and all the wretchedness which now hangs heavily over the hut of the pioneer would disappear. Thus the whole population would be elevated by so urbane and blissful a state of being, and to the attainment of which elevation the people have a right to exact the coöperation of their government.

Now, men, perverse and short-sighted in matters of liberalism, maintain that the giant stride which, in so short a time, has ranked this country with the mightiest nations, is to be ascribed to the very particular circumstance that government has not interposed in the action of the people in affairs of national policy. With just as much reason might they hold up the loose relations of the nomadic cohorts of Asia as an ideal for all administration.

It is to be hoped that nobody will mistake the object of these remarks, which can be none other than to lay bare the necessity there exists of placing every species of settlement (which is really a question of national economy, and which must be supervised with an eye to sanitary well-being), not only under government control, but governmental superintendence.

Allow me here to make a comparison: It is said that outposts are the eyes and ears of an army. The same similitude can be applied to the topographical corps, when considered with reference to the importance they are to government in regard to the opening out of new tracts of land for the furtherance and development of colonization, if a wish really be evinced of finally putting an end to a system which enriches the territories with the best blood of the pioneers.

I speak of a topographical corps * in the supposition that such a one will shortly be deemed a necessity. For, of all the high powers and cultivated states of this planet, America is the only power not in possession of such an institution—the United States Coast Survey being only properly designed for hydrographical purposes. It is to be hoped Congress will ere long give this the attention so important a subject deserves—nay, demands.

* Those who take an interest in the organization of a topographical corps, will find a complete treatise on this subject, entitled "*Memorial über Ingenieur Geographen Wesen*," by the author of this work. Braunmüller & Co., Wien, 1856.

REMARKS ON COPYING THE PRECEDING PLATES.

No one would attempt to learn drawing by written direction merely, inasmuch as to prescribe technicalities, however simple, a multitude of words would be required, and might, after all, be of very little service, as drawing can only be taught practically.

We will therefore only state that, in copying the tables V. to X., the scholar, if not already acquainted with the use of water-colors, will, by practical advice, learn all the necessary requirements in a short time; and, we may add, that the scholar need not be at too great pains to acquire pedantically the exact hue of the tints employed on these plates, as all colors in chromos are oil-colors; hence, his water-colors will always vary in shade to a certain extent, which, however, is of no consequence, if he only comes near to the general effect.

In finishing a pen-drawing, we may mention that the scholar must observe the characteristic figures and forms, taking care to enlarge them, as the pen and surface of the paper will never afford the facilities for a perfect finish, one which an engraver's instruments can accomplish on highly-polished copperplate.

Pen-drawings are, in general, only advisable for field-surveys and sketches.

A drawing must be executed by the pen, in cases where a reduplication is wanted, for which purpose photo-lithography is most effectually employed. In order to attain a higher finish, the drawing must be executed on a scale larger than that of the published charts. In this manner all roughness will disappear in the optical reduction of the photographic process.

PART IV.

THEORIES OF OROGRAPHIC REPRESENTATIONS.

The relations of the various forms of the surface, as described in the preceding sections, constitute, with the configuration of the ground, the basis for all tactical and strategical combinations. Together with the communications, and the state of cultivation, nothing is of more importance than the exact knowledge of the terrene, because upon its nature depends the deployment of troops, and their ability to operate. It is also of the greatest importance in the laying out of highways and railroads, as well as in the location of settlements.

Hill-drawing, styled in military science terrene drawing, must not only rigorously circumscribe the form of a mountain, or even of a part of it, but must establish an exact estimate of its different angles of inclination, the hypsometrical relations of one point to another, or, in other words, the relations in which hill and dale stand to each other. A correct terrene drawing must also render profile drawings almost unnecessary.

A correct representation of the configuration of the surface was, however, not so easily discovered, although the art of surveying had reached a high degree of perfection.

Major von Müller was the first to bring forward a theory of military topography, and classified the elevations as gentle, less inclined, inclined, steep, precipitous, and perpendicular, and applied distinct shading to each of these classifications.

The French began to represent their style of hill-shading with more plastic effect, inasmuch as they brought the law of light and shade, as in landscape, into application.

It was reserved to Major von Lehmann to bring the theories of hill-drawing nearer perfection, in so far as he carried further Müller's idea to represent the shading in such a manner that the

angles of inclination of a slope could be easily recognized, and this by the law of light and shade, illumined, however, by the supposition of a perpendicular light.

The oblique illumination would, as a general thing, have been preferable to the great mass of readers and lovers of cartographical representations, on account of its landscape-like appearance; nevertheless, when a knowledge of relative elevations was required, it was soon discovered that the oblique illumination in no wise came up to the requisite desideratum.

In order to show such distinctions, the scale of shading must differ according to the varied exposure to light, and eighteen different shades would be necessary effectually to express all features. Who could draw, who decipher them, with any degree of certainty? A perfectly correct delineation of nine different shades already requires a good deal of practice and skill. Compare Pl. XI., Fig. 10, *B.*, Lehmann's well-known model, which is carefully executed by curves of equal light, the angle of light assumed under an angle of 45 degrees, with the same subject, Fig. 17, illuminated by vertical light, and one will here soon discover a considerable difference in the effect which the true relative elevations possess. Still the contrast, where the shaded side coincides with the steepest slope, is not so striking as when the shade falls on the less inclined planes, as in Fig. 10, *A.*

General Dufour tried to remedy these defects by retaining the intense shading in all steep declivities, irrespective of the theoretical requirements of light and shade.

But the most ingenious improvement in characterizing the hypsometric relation of mountains was invented by the celebrated geographer, Philip Buache, in 1744, who proposed to circumscribe mountains with lines of contours from the foot to the top, as the ocean would do, supposing it could overtop a mountain, by a succession of upflowing circlets. This idea has established a general system of orographic representations, namely, by means of horizontal equidistances.

LEHMANN'S THEORY OF HILL-DRAWING.

Relief, or raised undulations, can only be expressed by the distribution of light and shade; and when the declivity of a slope is to be expressed, it can only be effected by supposing the same exposed to vertical light, when the relation of light to that of shade is in the same proportion as is the sinus versus of the angle of in-

clination to its cosinus. For the better illustration of this, imagine Fig. 1, *f q*, Pl. XI., as being a horizontal plane—it will receive all the vertical rays of light through the entire extent of its projection; but if the plane is inclined, like *f b*, it receives only just that amount of light that falls within the limits of its projection, *f i*; and should the plane be raised, so that it reached the perpendicular position, *f d*, it would stand completely without the reach of light, and would, consequently, be in utter darkness.

But, since the earth can only attain to an angle of 45 degrees of elevation, all above belongs to the unscalable domain of rock; thus Lehmann has arranged his scale of shading within this gradation, whereby the planes receive a double amount of black, or, geometrically speaking, the relation of dark to light proportions itself to delineate oblique planes, as does the angle of the refraction of light to its complement of 90 degrees, or as the double angles of inclination of the planes do to their complement of 90 degrees:

Inclination.	Angle of refraction.	Complement to 90°.	Proceeding ratio.
5°	10°	80°	1 : 8
10°	20°	70°	2 : 7
15°	30°	60°	3 : 6
20°	40°	50°	4 : 5
25°	50°	40°	5 : 4
30°	60°	30°	6 : 3
35°	70°	20°	7 : 2
40°	80°	10°	8 : 1
45°	90°	0	Black.

Experience, however, soon proved that in mountain-regions the entirely black shade was inconvenient, often obscuring or displacing the necessary lettering. To obviate this, the scale of shading was subdivided into ten parts, while the nine standard gradations were retained. The ratio of black to white is found by dividing the number of degrees by five for the black, and denoting the corresponding amount of white by subtracting this quotient from ten.

Thus we obtain as ratio of black to white, Fig. 4, Pl. XI.:

For 5° as 1 : 9
" 10° " 2 : 8
" 15° " 3 : 7
" 20° " 4 : 6
" 25° " 5 : 5
For 30° as 6 : 4
" 35° " 7 : 3
" 40° " 8 : 2
" 45° " 9 : 1

Fig. 5 represents a scale of hachures upon this principle.

In the law laying down Lehmann's scale of shading, it is established that not only the chief gradations, those from 5 to 5 progressive angles of inclination, but principally each slope between 0 and 45°, can be represented by hachures conformably to the angle of inclination—by the relation of dark to light. This has often been ignored or passed over, and all planes with slopes under 5° have been represented according to the relation of slopes of 5°, and by that means the capability of representing all the undulations of the ground to a less angle of inclination has been lost.

But, if we keep to the law, giving the width of the lines of shading with reference to the width of the interstices, as the angle of inclination to half its complement, we get for

1° black to white = 1 : 44
2° " " " = 2 : 43 (1 : 21½)
3° " " " = 3 : 42 (1 : 14)
4° " " " = 4 : 41 (1 : 10¼)

as the numerical expression of the slope.

Another and more practical rule is this: to enlarge the proportion of the white part for every degree 25 per cent.; i. e., for 4° + 25%, 3° + 50%, 2° + 75%, and 1° + 100%, consequently—the double distance of the above-graduated scale. Vide Fig. 9, graduated scale, or hachure metre.

CONSTRUCTION OF A SCALE OF ELEVATION.—Fig. II.

From a point, A, on a given line, A B, with A D as radius, circumscribe lines, making angles from 5 to 5 degrees up to 45°. At any distance from the line A B draw a line, C D, parallel to it. From the points of intersection of this parallel erect perpendiculars to A B, for example $x\,y$, which will represent the horizontal projections for the respective elevations, as in this case A y is the projection plane for 10 degrees.

Such scales are accurate enough for elevations of 100 feet equidistant, and on large scales; but, for shorter elevations, such as 20 feet, construct a scale as given in Fig. 9. To do so practically, use an inch divided into 100 parts. Inquire first into the proportional value for the slope of 45°, where the line of projection is equal to its height. This found, the others are easily defined by the following table:

The distance of the horizontals for			$2\frac{1}{2}°$	is nearly	$22\frac{1}{2}$	times	the	height.
"	"	"	5°	"	11	"	"	"
"	"	"	10°	"	$5\frac{1}{2}$	"	"	"
"	"	"	15°	"	$3\frac{2}{3}$	"	"	"
"	"	"	20°	"	$2\frac{3}{4}$	"	"	"
"	"	"	25°	"	$2\frac{1}{5}$	"	"	"
"	"	"	30°	"	$1\frac{5}{6}$	"	"	"
"	"	"	35°	"	$1\frac{3}{5}$	"	"	"
"	"	"	40°	"	$1\frac{2}{3}$	"	"	"
"	"	"	45°	"	1	"	"	"

Upon the same scale, prepare for each class of shading about 5 hachures, which will be of considerable assistance in comparing the hachures with the drawing in operation, or to estimate the relations of elevations on a drawing of a corresponding scale.

DISTANCE OF HACHURES FROM EACH OTHER.

The rule of Lehmann's scale of shading is applicable to all scales of construction. The object of this scale of shading is to express the relation of elevations so as to produce an exact impression of a surface, which can only be obtained when the hachures are in a proper proportion for optical effect; i. e., that they obtain the impression of tints by which the relief is effected; otherwise, when the hachures are too far apart, the drawing will have a lineal appearance.

In drawings, fifty hachures to the inch are taken as a general rule; a skilful draughtsman, however, can take as many as seventy-five hachures per inch in chorographical works.

Direction of Hachures.—Since hachures must not only express inclination, but also situation, they must be drawn in the direction any heavy body would take when rolling down the declivity, viz., the line of shortest descent. No rule is given for the length of hachures, which has been left to taste and convenience, except in cases of equidistant horizontal projections, where their length is limited. Experience and practice fix the limit of a hachure from $\frac{1}{8}$ to $\frac{1}{24}$ of an inch.

In order to draw hachures in conformity with the law of gravitation, it becomes necessary to construct horizontal projections of the inclined plane (see Fig. 11, Pl. XI.), which are always intersected by the hachures at right angles. In Lehmann's method,

the horizontal curves serve only to delineate the form. All points in a horizontal zone are on the same level.

In shading, it is most convenient to begin at the top of the hill, and the draughtsman will take care, by connecting the hachures on the upper horizontal zone, to arrange the shading in such a manner that the lower hachures range at intervals upon the upper row, in order to prevent a continuous prolongation.

If the formation of the slope is very convex or concave, with a gently descending ridge, auxiliary horizontals will have to be drawn intermediately. (See *x y*, Fig. 11.)

This figure also illustrates the curvature given to hachures, in order to meet the horizontals at right angles—as the starting-point would in no case conform to the rule, when drawn in a straight line, as shown in *s* and *t*—but when curved it will cut through all horizontal lines in the required direction.

In order to draw these curved hachures correctly, it will be well to sketch their directions first in pencil conveniently apart, as in Figs. 11 and 15.

According to the theory of Lehmann, all hachures, as well as all spaces, ought to be rectangulars, and consequently parallel throughout; yet we have seen that, in slopes of a convex or concave surface, this rule cannot be carried out, and the estimate of inclination has rather to be taken from the total effect of the slope, since the ratio of black to white is disturbed.

The summits or tops of hills are usually of small extent, and often nearly round or oval, consequently the hachures appear radial, and will produce an effect not corresponding to the true conformation of the summits. If, therefore, the inclination is but of a few degrees, the best remedy is to make every second hachure shorter, as is shown in Fig. 14, opposite *a*.

The hill-top, *a*, in Fig. 14, is drawn after Dufour's; the other three, after Lehmann's system.

An abrupt declivity, as in section *a b* of this group, has, of course, to be rendered by a shading corresponding to its inclination.

One of the greatest difficulties for the beginner is the equal distribution of hachures. This depends upon the gift of a good eye; otherwise, long practice is required in order to effect this first condition of a correct shading. To facilitate this difficult task, the use of a little instrument, called roulette (a denticulated wheel, suitably mounted), will be found very convenient. By running this wheel along the horizontal curve, its teeth will make in-

dentations, marking off the places for hachures. The demarcations by the roulette must consequently correspond with the number of hachures required per inch.

RELATIVE SITUATION OF TWO PLANES.

The line where two inclined planes meet is called the line of intersection. It represents either the ridge or the very opposite, the cavity. This latter case admits of four different conditions:

1. If the cavity, or valley, etc., is horizontal, then the hachures project vertically toward it.

2. But, if the line of intersection is inclined, then the hachures will be oblique.

3. If the intersecting planes are of equal inclination, then the hachures are also of equal inclination; as, for instance (Fig. 3, Pl. XI.), if A B is the line of intersection, and A C and A D the intersecting planes, then B C = B D, or the angles at the intersection are equal.

4. But if the inclination of one plane is different from that of the other, the angles at the line of intersection will also be unequal; i. e., larger on the side of the steeper declivity, and inversely.

OROGRAPHICAL REPRESENTATION IN HORIZONTAL PROJECTION.

Attempts have often been made to represent the configuration of the ground by means of equidistant horizontal planes, without any vertical shading, but they always proved unsatisfactory whenever details had to be expressed with only approximate exactness. For this purpose, the vertical distances between horizontal zones must be very small, in order to encircle every detail of importance, which otherwise would be lost sight of.

We represent in Fig. 8, *b*, Pl. XI., a scale of inclination for a vertical distance of 5 feet in 1 : 20,000 its natural size. This is already a large scale for topographical maps; however, it will be readily seen that it is impossible to carry such equidistances throughout all grades of declivities.

Having to recur again to this subject, we will only mention that another objection to the system is its want of plastic expression. To remedy this defect, a kind of shading has been introduced by intensifying the horizontal curves in accordance with the gradation of the slope. This essentially improves the steeper grades, but less elevations remain in their feeble impression.

Nevertheless, the system is of great value in various respects,

when the equidistant horizontal planes are carefully laid off by actual surveying.

In order to make the hypsometrical relations of a country conspicuous; i. e., to show the elevations at a glance, and with exactness, it is advisable to mark, by prominent contours, the horizontal curves at certain heights, for instance, in a hilly country at every 100 feet; in a mountainous district, at every 100 metres (or 300 feet), and to distinguish them by figures relative to the height above the level of the sea.

EQUIDISTANT HORIZONTALS, COMBINED WITH VERTICAL SHADING.

Lehmann's method has been further developed by its combination with the horizontal system, for, with Lehmann, the horizontals neither indicate any absolute height, nor do they limit the length of the hachures; by showing the general outlines of the conformation, they merely assist the draughtsman in finding the correct direction of the shading-lines.

But, with a drawing of equidistant horizontals, the hachures must intersect accurately, so that when the auxiliary outlines of these horizontals are removed, the horizontal zones may be considered as so many subdivisions. Their relative heights are thus easily found, avoiding of course those parts where auxiliary curves have been used.

As regards estimating an elevation, this method is most serviceable when the projection of the vertical distance is known, and a comparison with a scale of horizontal projections is plainly measurable, but not so with a scale of shading, where the least difference is of considerable moment. In this uncertainty a combination is sought for, whenever time permits a construction of this system.

CONSTRUCTING PROFILES.

From a plan or map drawn after the horizontal system, no difficulty is experienced in taking a profile, all necessary dimensions being at hand. The simple procedure is this: Draw a base-line at a suitable distance from and parallel to the line of section, and let perpendicular lines from every point of intersection of the horizontals with the line of profile, fall upon it. Set off from the base the corresponding elevations upon these verticals, and the points which determine the outline are found. (See Fig. 15, A B.)

This work becomes more difficult in a plan constructed on the

principle of vertical shading. The vertical measures are wanting, and have to be supplied by the use of the inclination-scale.

GENERAL DUFOUR'S SYSTEM.

General Dufour, the distinguished Swiss topographer, has not, to my knowledge, published any particular system as a guiding rule, but has issued a topographical map, representing the Canton of Geneva on a scale 1 : 25,000. The undulating surface is executed in a style similar to one once projected and published by the War Department in Paris; but, as the above-mentioned map is the only one executed in this style, it has been thought proper to confer his illustrious name upon the system as here established.

Our system is not that of the French one, but is constructed on a simple geometrical plan. Its object is the same, viz., to acquire more distinctness for the lower grades of elevation, and to preserve for the higher grades sufficient effectiveness in shade, without interfering with the necessary clearness and explicitness in all other topographical details, as well as to afford a plain reading of such words as may be placed in the midst of shading expressing the highest declivity.

We copied, in Pl. XIX., a part of this topographical map of the Canton of Geneva, as an example of spurs of mountains, with this modification, that a vertical illumination was adopted instead of the mode of light and shade.

The scale of this proposed system is constructed in the following manner (see Fig. 6, Pl. XI.): First, we give two parallelograms, such as in Fig. 4. The double width of this, as is shown in fg, is proposed for the class of 5°, but at 45° only $\frac{2}{3}$ of the width of one parallelogram is wanted. Now connect point d with b, and where this line intersects the lines of projections, as, for instance, in e, the proportional division for 10° is found, and so on up to 45°. It will be seen that, whereas it takes double the space for the expression of 5° of inclination, only 25 hachures are given per inch, while 50 hachures are taken as a standard in Lehmann, but by 45° our scale here acquires 25% more hachures, namely, 75 per inch. This illustrates the chief difference between these two systems. Fig. 7 illustrates a scale of this system. In regard to the scale of shades from white to black, it will be observed that the increase of the intensity is not quite so distinguished as in the scale of Lehmann; but by means of contraction of the hachures into finer

divisions, far more prominent—so as to produce abruptness, which certainly misrepresents Nature, and had therefore to be rounded off, which was attained by interposing short hachures jointly on the respective contours. This, not being essential to the system, must be looked upon as a technical remedy, which can be easily recognized in the model hill of Pls. XI. and XIX., and in the group of hill-tops, Fig. 14, *a*.

COLONEL OLSEN'S SYSTEM.

Colonel Olsen has modified the horizontal system by combining, according to circumstances, two or more of the horizontal zones into one, and by designating such combinations by a progressive intensity in shading, so as to see at a glance the number of zones thus combined, and therefore facilitating the estimation of the proper height, as well as the angle of declivity. In this manner the topographical map of Denmark in 1 : 20,000 has been executed.

In Colonel Olsen's "Topographical Tegnekunst" no mention is made of this system; yet, since the above maps have been drawn under his supervision, no hesitation is felt in making use of his name in this connection.

From these maps, however, it cannot be ascertained whether their contractions have been applied to certain gradations or not. We have assumed this to be the case, in order to render the scale more systematical.

On a flat, gently-undulated surface, the horizontals must be taken at small vertical distances, to gain a clear expression of its configuration. In the above-mentioned map, the vertical distance is 5 feet; and, large as this scale is, it would be utterly impossible to retain it through all grades of elevation, as, at a glance in Fig. 8, *b*, Pl. XI., a scale of inclination for 5 feet vertical distance in 1 : 20,000 will be seen, where, even at a declivity of 15°, the horizontals become so crowded that a distinct drawing is out of the question.

The scale, therefore, has to be so constructed that at 15° the first contraction takes place, and the vertical distance subsequently amounts to 10 feet, and the first class of shading is applied. This is retained to 20° of inclination. Thus, always grouping two classes together, a scale of five distinct shades was obtained, namely:

First class, from 5° to 10° inclination—5 feet vertical distance up to 15°, left white between the horizontal zones.

Second class, from 15° to 20°—10 feet vertical distance up to 25°, with first class of shading.

Third class, from 25° to 30°—20 feet vertical distance up to 35°, second class of shading, with double intensity.

Fourth class, from 35° to 40°—40 feet vertical distance up to 45°, third class of shading, with triple intensity.

Fifth class, 45° and 80 feet vertical distance, fourth class of shading, of quadruple intensity.

Olsen took entirely black for 45°, as Lehmann did, which ought to be abolished.

Fig. 8, *a*, is a scale of shading upon the above principle. The advantages of this method are:

1. Saving of time and expense, which is very important, whenever a work of great extent is undertaken.

2. It affords a quick and precise review of all conditions with regard to declivities, and at the same time gives sufficient effect to the entire configuration of the surface. (See Fig. 16, in Pl. XI.)

This system may be said to be especially adapted to military purposes for its marked delineation of those parts of the terrene which are practicable for troops of all arms, and their most important evolutions and effectiveness of their special arms.

FIRST PRACTICAL EXERCISE IN HILL-SHADING.

To the student thoroughly acquainted with the principle of representing the configuration of the ground, the exercises in shading should commence. This is the only part in topographical drawing which requires a training of the hand and a just eye. To depict hundreds and thousands of hachures, which must be of equal distribution from centre to centre of each shade line, is a pretty hard task, not only for a beginner, but even for the practical draughtsman. To facilitate this, we now propose to give the student practical aid in using a roulette, as previously recommended.

When the student is able to perform these exercises in an easy and off-hand manner, he may practise the scale of shading, and train the eye to estimate the degrees expressed by the given hachures, and the relation of forms to each other. After some progress in hachuring, hill-drawing should be commenced.

In many schools, beginners are required to practise shading by representing pyramids, cones, sections of a globe, etc., which is very fatiguing, very difficult to execute, and which is, by-the-by, in no relation to the proper conformations of natural hills; the

student may as well acquire improvement by copying elevations as they actually exist, and thereby familiarize his eye with the geological construction of the earth's surface.

CONSTRUCTION OF MODELS.

A very good method for forming correct ideas of the objects represented by hachures, is to prepare a model previous to the drawing. Colonel Streffleur describes a very simple mode of constructing models. The contours of the horizontal curves are traced on gelatine and printed on paper, pasteboard, or wood. The thickness of such material must naturally correspond with the required height of the horizontal planes. Then each zone will be cut out and pasted one above the other, according to its proper situation.

Of course, the model will have a terrace-like appearance, which, however, does not prevent a complete expression of the characteristic conformation. If it is desired to reproduce the actual form, the graduated interstices may be filled up with modelling-wax or plaster of Paris. It would be worth while, however, to make a cast of the model in its terrace-like form; in which case the model had better be varnished to prevent adhesion of the plaster. Fig. 2, Pl. XIII., is recommended as a first attempt at modelling; this part of a hill, and all others, with the exception of Fig. 4, are projected in the scale of 1 : 15,000, and the vertical distance of the horizontals is 4 metres. Each fifth horizontal curve is distinguished by a marked contour, thus representing 60 feet equidistances; the other auxiliary curves can be easily recognized by the marks of separation between the upper and lower row of hachures.

In the construction of models, in regard to the actual measurements of the vertical distance of the horizontal zones, the characteristic conformation of the surface will be of decided influence; as, for instance, gentle undulated ground will admit of only short distances, as from 5 to 20 feet, in order to render proper representation, while steeper conformations will be sufficiently and accurately represented by vertical distances from 30 to 100 feet.

SECOND EXERCISE OF HILL-SHADING.

After completing the model, as heretofore described, the student should now draw the same subject with hachures of Lehmann's scale, for which purpose the same tracing may be used in depicting the horizontal zones on paper.*

* A good impression requires no retracing in pencil. The work of finishing may begin directly.

This tracing can be more easily prepared by means of gelatine paper, and decidedly more expeditiously than by copying by means of squares, and has further the advantage, if the first attempt in finishing should fail, of replacing, without loss of time, the contours of the same subject again, as such tracings stand several good impressions. The necessity of trying the same thing over again will often happen to beginners, especially if the student tries to draw hachures by a single pressure of the pen with the requisite force, and which is the only means of securing distinct and clear strokes; all attempts at finishing hachures gradually ought to be avoided, as they confirm the uncertainty and receive in the end a fringe-like appearance.

The various systems represented in Table XIII. are not intended for immediate practice, but for selection only. The student should not feel obliged to render the acuteness of hachures as in the original, as paper is not metal, nor the pen a burin. The chief object in view should be an understanding of the relation of shade and light, and of the inclination expressed.

THIRD EXAMPLE OF HILL-SHADING IN PL. XIV.

In order to attain a proper understanding of the somewhat complicated conformation of this part of a mountain, it is highly commendable to construct first a model thereof, in the manner already described. In a class, the scholars can divide the work, each cutting out some of the horizontal zones, and, when the model is completed, several casts may be prepared at little expense. But, without the aid of a model, the beginner cannot form a correct conception of the configuration of this mountain-slope.

Perhaps the lesson here presented will appear a difficult exercise in shading; but after its plastic development, the greatest difficulty—an understanding of the true form—has been overcome, it merely requires application in the execution of the drawing. After this task is accomplished, the student will become more self-reliant, and thus improve in technical drawing. The variety of natural forms in this configuration cannot fail to interest and encourage to new attempts, if the first results prove unsatisfactory.

In modelling this group, it is not necessary to represent each horizontal. The vertical distance of the horizontal zones in the original is ten feet, and by taking distances of twenty-five feet, will very well harmonize with the prevailing details.

FOURTH EXAMPLE OF HILL-SHADING IN PL. XV.

This example, like the preceding one, has been taken from General Hofbauer's "Topographical Drawings" (an extinct edition), and represents Bisamberg, north of Vienna. The form of this hill serves as an excellent subject for a model. The author of this work, during many years of labor in his profession, has had occasion to draw a great many varieties of configuration, but never met with a more interesting form of mountain, which caused it to be used as a model, in the belief that the student would find encouragement in his efforts, when combining the useful with the agreeable. An ungrateful subject, though correctly represented, never affords much satisfaction, nor calls forth a desire to excel.

In this case it is also advisable for the novice to proceed with the model before preparing the drawing. Thus he must first construct the horizontals, which he will find with the help of the profiles, which are given in equidistances of 100 feet. He should reduce also the equidistances of 100 feet, distinctly laid down on the preceding Pl. XIV., to the corresponding scale, and carry the result to the part in Pl. XV., which will serve as a guide in continuing the remaining horizontals.

We selected this grateful subject of a hill example, to serve as an illustration to all the practical scales used in topographical institutions, and believe thereby to have given the student the best means of acquiring an instructive view, in comparison with the true conformity in nature to a reduced or so-called generalized representation.

DRAWING OF ROCKS AND GLACIERS.

As rocks are generally of such great elevation, that their ascent by man is impracticable, the topographer takes account of their direction and extent only, without inquiring into the nature of their forms, and endeavors, as well as possible, to give his drawing the expression of Nature by characteristic contours of clefts, peaks, terraces, etc. As this is done in a landscape-like style, much practice and skill are required to execute it in a satisfactory manner; therefore, as it cannot be expected that a topographer possesses ability in this kind of free, off-hand drawing, we propose a simple hachuring, as will be seen in Fig. 3, Pl. XIII., and in Table XVI.

The same difficulty prevails with the representation of glaciers. To explain their conformation in a clear manner, Professor Agassiz and Colonel von Sonklar have adopted a method which is

reproduced in Table XVI. The hachures express, in the best manner possible, not only the configuration of the glacier, but also the direction of its motion throughout. To execute this with the requisite distinction, the separation of the elements by colors is necessary.

A drawing or engraving in black should, to distinguish the undulations of the glacier from those of the surrounding formations of the valleys, be characterized either by lines running horizontally or by punctuation, as shown in Pls. XXIII. and XXIV.

If a drawing is to be finished in colors, the use of sepia is recommended for the representation of rocks, and blue for that of the glaciers. Of course, this must then be executed in landscape style. The contours, clefts, and other details, are first drawn in ink, then the sepia laid on at the contours, and washed downward. No further rule can be given, as individual taste will decide what is suitable.

CONCERNING THE REDUCTION OF THE TERRENE FROM LARGER INTO SMALLER SCALES.

In the Introduction, we have specified the various categories of cartography, and are aware that a reduction answering the purpose has to be adjusted. When a reduction has to be made, it is done by means of a pantograph, or by the help of the camera of the photographer, or must be drawn by squares.

The more the given scale diverges from the original, the more difficult will be the proper solution of the task, which is any thing but a mechanical one, and should only be essayed by an experienced topographer. From him is to be expected that he be not only practically familiar with most orographic appearances, but that he also possess the theories of geology. He will thus be enabled to distinguish when considerable deviation of forms arise, what is *absolutely inadmissible*, what *conditional*, or what *really* has claims upon the representation.

In the theoretical development of hill-drawing, one inference follows close upon the other, and the same mathematical precision is exacted, therefore, for all parts of the theory; but, in their application to the representation, the requirements of the theory separate themselves into principal and secondary, which are subordinate to each other. According as a deviation has an important bearing upon primary or secondary, the signification of the same will adjust itself.

The purpose of the topographical representation of the ground

is to give a summary picture of the unevenness of the surface, which with geometrical correctness represents the entire superstratum, with its divisions into forms and sections, in horizontal projections.

The means to effect this is the hachure, the strength and direction of which are determined according to the rule, and indicate the situation and inclination of the planes.

Every deviation therefrom is a fault against the theory; but, notwithstanding deviations in matters of detail, it can always, with regard to contours and sections, sufficiently correspond with the entire representation when contours and sections are expressed.

The proportions of the scale, and especially the more reduced it is, change necessarily the image embodying the construction of Nature into one of mere abstraction.

The draughtsman has now to decide what is essential, what is unessential, what is subordinate in detail, and what properly goes together. It is now a question of the right knowledge of the true, in contradistinction to the seeming sections. Considering the entire terrene to be represented as a body, it would as such consist of various members. Every range of heights consists of several connected elevations, between which valleys extend, and every one of these elevations may have its accessory valleys, divided into various parts, branching off from the most prominent elevation, or forming other points of distinction in the scenery, which should not be omitted. Consequently, it is one of the first conditions to a correct representation of a terrene, that the various parts in their situation, connection, and extension, should be correctly given, and, as the objects occupy not only different positions in the terrene, but have various relations of altitude, under the name of ridge, summit, etc., these distinctions also should be correctly indicated.

Often the scale in which a drawing is to be projected renders a contraction of various forms under a generalized one necessary.

It should be observed that one portion of surface is more varied, and its formations more scattered, or of much smaller dimensions, than another; and has to be positively expressed in accordance with these circumstances. It should never be attempted to represent every sort of configuration with the same summary concentration of details, without regard being had to the peculiarity or characteristic of the nature thereof. The question is also not to lose the principal contours. If, however, the scale is so much diminished

that even these can no longer be expressed, topographic representation ends, and some conventional sign is the sole indication of a mountain-range.

Chorographical, and especially general maps, already too diminutive to admit all structures of the terrene, but otherwise still too large in scale to represent the orography in a conventional design, have given rise to a style which is called among practical topographers the characteristic representation of terrene. Only the most prominent summits are marked, while the intervening elevations appear as one ridge. Declivities are connected as one slope; the normals, i. e., hachures, are and cannot be any longer the representative of the actual inclinations, but give rather their average relation. The contours of mountain conformations are lost in general outlines, but the characteristic features are preserved.

The perception of these various relations requires a thorough knowledge of orography, not only of its outside appearance, but also of its geological conditions. The former can only be acquired by practical surveying, the other by the study of its theory, as well as by practical observations.

In order to impress the student more effectually with the manner of reduction to a smaller scale, the example of the Bisamberg has been reduced to various customary topographical scales, such as (see Pl. XVII.) from 1 : 5,760 to 1 : 14,400; also 1 : 25,000 to 1 : 72,000; and to 1 : 288,000, the latter the scale for general maps.

In the reduction of 1 : 72,000, the relation of topographical details is nearly as distinct as in 1 : 25,000; but at 1 : 288,000 such distinction is no longer possible; the details become too minute, and could only be produced by the help of microscopic power, and therefore impracticable for both those who should execute the work, and those who should read it—as will be readily recognized in the example marked *a*. In *b*, a contraction of details has taken place, but the principal form preserved. By the contraction of parts into one slope it will be observed that they are no longer a correct representation of the true conformations of these slopes; but, as they are constructed by hachures, which are expressive of positive forms, it is evident that the hachures are not the best means for generalized hill-drawings, at least in the sense of the previous description. We propose, therefore, a more advantageous manner in sketching the outlines, as in *c*, and to give, or rather to bring out, the principal

form in relief, by inking with a brush, in accordance with the requirements of the general declivity.

We have now to treat about reduction from originals projected in equidistances.

Many topographical details, of importance in military as well as in technical respects, are lost where a great vertical distance of horizontals has been assumed; moreover, the correct delineation of orographic forms becomes defective. The converging of contours may not prevent the usefulness of reductions on a very small scale, but in drawings of 1 : 72,000, which still maintain the character of topographical maps, the features of mountain-forms must be preserved.

As an illustration, see a map of the peninsula, executed in 1 : 40,000 (Point Lima, California), which was reduced from a survey in 1 : 10,000, with equidistances of 20 feet. If in this case the reduction of 20 feet equidistances were given only, all details intersected between these horizontal zones would be invisible; they had to be drawn according to their situation. This is particularly the case in places where the rock projects out upon the surface.

In the reduction of this terrene to a scale of 1 : 40,000, it was found convenient, in general, to retain the vertical distances of 20 feet; but, in elevations of 35 degrees and more, the horizontal contours came so close together that the hachures had to be drawn through 2 or 3 horizontal zones. In the reduction to 1 : 80,000, the same vertical distances could not be retained, as is demonstrated in Fig. *h*, in which the vertical distance of 20 feet has been carried out.

If, now, the distance of horizontals were increased to 40 feet, all objects of less inclination would appear much less in their true form; the details of configuration would be lost between such spaces. This proves that the systematic use of vertical distances, under all circumstances, is not compatible with a due expression of the actual relations of a terrene; and that, since the contours of a surface best express the characteristic form of elevations, more attention should be given, in a reduction, to the preservation of these, than to the results of horizontals.

UPON THE COPYING OF LARGER TRACTS OF TERRENE.

The exercises in shading given in former plates will be sufficient to acquaint the student with the theory of hill-drawing, but can-

not give him a full knowledge of orographical design. The study of Nature is indispensable, and some practice in surveying is therefore absolutely necessary. But the locality where he pursues his studies being seldom propitious to the study of the manifold mountain formations, it has been thought desirable to select from excellent surveys, and to classify by degrees of development, a series of formations in Tables XVIII. to XXIV., in which are represented, in vertical dimensions, hilly or undulating country, spurs of mountains, mountainous country, highland, alp, high mountains, and ice-mountains.

A few observations in relation to copying these plates may save time and facilitate results. The tracing should be prepared on gelatine paper, in the manner heretofore described. In works of large extent, the retracing of the contours on the reverse side, for the purpose of obtaining a positive impression, takes much time. If the student does not like to proceed in the manner of engravers, to draw directly after the negative, the following manipulation is recommended: After preparing the tracing, take very fine paper and rub this with a hard brush, so as to create a surface which will readily adhere to the lead. Then place the tracing on this paper, and by a polishing-steel produce an impression. Transfer this impression, by the same power of the polishing-steel, to drawing-paper, which will then produce a positive impression like the original in question. The manipulation of the polishing-steel requires great care; and, therefore, when a lithographic or plate-press is near at hand, the transferring operation should be effected thereon, which will procure a successful copy.

In copying the examples given in these tables, the student should pay attention to the proportions only, according to the scale, and not to the fineness of hachuring.

It is recommended, in copying Table XVIII., which is projected in equidistances of 5 feet, to carry out the same in horizontals of 10 feet—Pl. XIX., which has equidistances of 4 metres, in such of 10 metres. Pls. XX. and XXI. in about the same proportions as the originals. Pls. XXII. and XXIII. have prominent equidistances of 100 metres, and they are subdivided into horizontals of 10 metres. They can be conveniently copied in horizontals of 20 metres. Pl. XXIV. is executed in equidistances of 15 metres, except the *firn* and glaciers, which are interpunctuated in equidistances of 3 metres, in the gentler slopes, but of course could not be carried on in this subdivision in the more abrupt glacial declivities.

PART V.

OROGRAPHICAL TERMINOLOGY.

OROGRAPHY treats of the manifold forms of the solid portion of the earth's surface as it projects from the level of the sea. The diversity of these formations is so great, that science had to introduce definite terms, by means of which clearness as well as brevity may be attained in any description of terrene.

In topography, *plane* means not only a perfect level, but any inclination up to two degrees is included in this term. In a military sense, any portion of the surface where troops within range cannot be placed under cover; i. e., unseen from the enemy, is called a plane. The absolute elevation of such planes may be very different; if very large, they are named table-lands (plateaus); if traversed by minor elevations, they are called undulating, or rolling, when these characteristics become more prominent, though the latter term is also applied to hilly land.

A plane is called *open* when nothing thereon obstructs the view or prevents free access to any part; and *covered*, if to a considerable extent it is occupied by woods, orchards, buildings, etc. If traversed by running water, ditches, marshes, etc., it is termed an *intersected plane.*

Isolated elevations, when small, are called *hills;* when greater, *mountains*—but what dimensions exactly determine this distinction cannot be stated with precision. It depends much on the locality; for what the Hollander would consider a mountain, the Swiss would scarcely take for a hill. Nevertheless, attempts have been made to numerically fix this relation, and it is pretty generally accepted that elevations of a relative height of some hundreds of feet only are called hills.

A multiplicity of hills receive the names of *hill-chain, hill-group,* or *hilly land,* and connected mountains are called a *mountain-range.*

Every elevation of the terrene presents four essential parts, with greater or less distinction:

a. The uppermost portion, the *summit*, which, in accordance with its geological structure, presents very great diversities in aspect and conformation, and therefore is designated by almost as great a diversity of names, such as cone, peak, point, dome-shaped, roof-like, flattened, etc. The mountain-summit, especially when clearly defined in its outlines, and visible from a considerable distance, is of great importance as a guide to the mariner (when situated near the shore), and is also of importance to the military, for various reasons.

b. The brow, viz., the boundary-line between the summit and the declivity. Allowing a view of both, it is often more appropriate to the tactician than the summit itself. Here, any further ascent may be effectually impeded.

c. The declivity, or slope (with a number of other names, partly local, partly indicating its nature), is the most important part of the mountain. Its principal forms are: the continuous, the convex, the concave, the undulating, the hollow-shaped, the terraced, the furrowed, the precipitate, the perpendicular, the projecting, and the mixed.

A perfectly-continuous slope occurs but seldom: the mixed one is the most frequent; that in the form of a terrace occurs in mountainous countries only, or where it has been produced artificially by man, as, for instance, in vineyards. On the other hand, the convex or concave forms are those most usually found in mountains composed of soft material, the sharp edges being naturally rounded off by the effects of rain and frost; the *débris* is carried down to the foot of the hills, thus flattening the slope. For this reason, the angle of slope of most hills seldom exceeds 45 degrees, and very few attain to that degree. In mountain-districts, or highlands, however, the pure concave or convex forms are those most frequently met with, the latter more especially when high mountains enclose narrow valleys, whose rapid streams, when swollen by rains, overflow, and, washing the shelving of the mountains, produce a convex slope.

The form of the slope is independent of the height of mountains, for those having flat slopes may be very high, and others with steep slopes very low, and *vice versa*. The angle of inclination which the slope projects into the horizon forms the most important data from which we derive the tactical value of orographical forms.

We insert here a table showing these values, as depending on the proportion of the horizontal projections to the heights, taken from Reichlin von Meldegy, and partly from Lehmann:

Proportion of Vertical Distances.	Elevation.	TACTICAL PRACTICABILITY.
1 : 24	2° 23′	Has nearly the same tactical value as the plane.
1 : 12	4° 45′	Accessible to all arms without great exertion; more difficult, however, for cavalry charging down-hill. Artillery-fire is more effective down than up hill.
1 : 6	9° 27′	Cavalry charge down-hill almost impossible. Heavy artillery, with the usual number of horses, move upward with difficulty, and will have to use brakes going down. A gun placed at the foot of the hill cannot be pointed toward the slope or the summit of the hill, without a special contrivance.
1 : 3	15° 16′	Passable for cavalry, though difficult in ascending, and slow in descending, and with great care. Double teams necessary for guns and loaded wagons.
1 : 2	26° 34′	Impossible for infantry to move with closed ranks, and confines them to the use of their fire-arms. No regular evolution practicable for cavalry. With a good start, a single horseman may run up if the slope is short. Impassable for guns or wagons, without particular contrivance.
1 : 1	45°	Sharp-shooters and light infantry used to climbing, and, if the soil is of soft material, with the use of their hands, may succeed in reaching the crown of an embankment, but with great danger of falling.

d. The foot is the continuation of the slope, with which it forms the transition into the plane. It usually ends at 10 to 15 feet above the plane, with a less angle of inclination than the real slope, owing to the accumulation of the *débris* from above. Under the action of water, however, this part of a mountain makes an exception to the general rule. It then appears as rising under a greater angle of inclination than the slope itself rises in the opposite direction; sometimes even in the form of a steep bank. In other instances, the foot occasionally projects into the plane in the form of terraces; and, if the distance is considerable, it becomes of importance to the tactician, especially when the position of this extended foot, or slope, outflanks the slope of the real mountain. Advantage and disadvantage, for an offensive as well as for a defensive party,

arise from this extended form of the foot. If it facilitates the approach to the slope, the advantage is with the assailant; but, if it commands the plane beyond, it becomes a bulwark, and is more effective than the crest or summit of the mountain, on account of its raking fire, while the shots fired from a higher position are more or less ground-shots (Stechschüsse).

Manifold as the different kinds of slopes are, they become still more so by combination. If two slopes meet under a very obtuse angle, and run gently into the plane, it is called a *hill-tongue.*

If they extend gibbously, with a precipitous fall, it is called a sharp corner (as Fig. 10), or nose (Fig. 7); if the edge is very sharp, it is then generally rocky, and called a ridge. If two planes meet under an ingoing angle, that place is called a *water-rift.* If these planes are embayed, they form a *trough* (mould), (Fig. 8), and, with steep slopes, a *funnel*, sometimes occupied by small mountain-lakes. *Ravines* are indentations formed by steep declivities; if found in high, rocky slopes, they are generally rough and stony, and become more so the higher they ascend. Sometimes they form the beds of small mountain streams and cataracts, by means of which the summit of otherwise inaccessible mountains, as also the opposite slopes, may then be reached. Covered ravines, or "defiles," often afford opportunities to reach the summit undiscovered, more or less protected from the enemy's fire. They favor, all things considered, not only secret movements in general, but especially offensive operations, and are therefore of considerable value, and not to be overlooked in the exploration of mountains for tactical purposes. A ravine, so steep and deep that it cannot be crossed by troops without artificial means, is called an *abyss*, and, if very narrow, and of great depth, a *chasm.* An *avalanche* is an accumulation of sand, earth, and stones, which extends, parapet-like, from the mouth of a ravine; they are found to a great extent in Alpine regions only, and are deposited there yearly by snow and water. Waters emptying from the ravines cut deep into the avalanche (Fig. 12).

e. Hill-slides, Land-slips, Caving-in of Earth, Caves.—Through clefts and ravines, or by other means, water sometimes penetrates into the rocky masses, percolates porous stones and strata, and, descending lower and lower, seeks an outlet. The masses thus mechanically and sometimes chemically loosened, in course of time, give way to the pressure from above, and the result are land-slides. The dissolving power of water, and still more that of frost, gives

us a proof of their effectiveness, which is seen in the appearance of the bowlders in the Alps, and other high mountainous regions. Here lie scattered about stones of every size, covering the slopes which lean against the rocky walls. The mountaineers give them the name of "Steinhalden." When avalanches break loose from them, they carry the stones far into the valleys.

Another feature of this dissolving power of water is seen in the so-called "Karrenfelder." On the plateaus of the Alps (where these are composed of chalk) are frequently found narrow perpendicular furrows, from four to five metres, sometimes so close together that the spaces between them form narrow ridges. They are very dangerous to cattle, and, in many places, are fenced in for their protection. They originate, probably, from perpendicular clefts, common to chalk-cliffs.

Depressions—perpendicular sinking in of the earth, producing funnel-shaped cavities. They happen most frequently where compact carbonate of lime, or gypsum, is underlying; also in mining regions, and in places which have been undermined by volcanic fires, or burning coal-mines. Nowhere is this caving-in more frequent than in the limestone region on the plateau between Trieste and Laybach. This great, sterile chalk-plateau is almost entirely without surface water, covered with innumerable blocks of stones, evidently produced by the breaking up of the layers, which often in winding rows lie one behind the other, thus showing plainly the course of streams and rivers.

Caves and grottos are horizontal, inclined, or sometimes even perpendicular spaces in the interior of mountains, and are of many different kinds in regard to their extension and formation. The caves in the Atlas Mountains became notorious in the wars of subjugation of the Arabs by the French. They were opportune hiding-places for the Arabs, till the French discovered them, and filled them with smoke, thus converting a shelter into a tomb.

Caves are a very important phenomenon to geologists. For a further description of them, we refer our readers to works on that subject.

Valleys are hollowed spaces which separate the heights, and may generally be considered as the natural drains for the waters of the continents. They begin partly as distinct elongated ravines, containing small mountain-streams, and gradually extending in width, and bounded by slopes more or less steep. They are partly flat, without streams, only now and then marshy. The bottom of

a valley is that rather narrow part, enclosed on the sides, serving mostly as a channel for the streams, and rising as it approaches mountain-ridges. It is remarkable (and in regard to the formation of valleys rather important) that, in some mountainous districts, the bottom of the valleys, be they wide or narrow, generally rise in a very uniform manner. Broad valleys with flat bottoms form planes of more or less extent; others are closed in by heights. Valleys are flat, wide or narrow, shallow or deep. Their direction is straight, or winding; they often present a remarkable parallelism of their sides. The position of a valley is generally designated by the position of its ends in regard to the compass. Valleys are classified thus:

1. *Main valleys*, running from the principal mountain-ridges toward the river, and side valleys, running from a mountain-branch toward the principal valley. They have this peculiarity, that they are often wider in the middle when they receive small side valleys than at their egress from the mountains. Main valleys are generally enclosed by high slopes, or accompanied by mountain-chains. Small valleys in highlands are mostly very narrow, rough, and enclosed by slopes reaching down to the valley-stream—thus rendering their beds very narrow. At the sources of rivers, they form deep ravines, rent by torrents.

2. *Longitudinal and Transverse Valleys.*—The former run parallel with the principal mountain-chain. They are mostly found without any gradual descent, frequently showing large rifts, and are covered with rubbish and rocky fragments. They are nearly always separate principal formations. In longitudinal valleys, the surface falls or rises, either from both sides toward the valley, or it rises on one side and falls on the other toward the valley.

Transverse valleys run nearly always at right angles to the principal mountain-chains; sometimes they intersect them. At the outlet of large transverse valleys, long and wide lakes are often found. Transverse valleys are especially adapted to geological researches, since, by deeply-rent clefts, they cut through all the layers, showing plainly their cross-sections.

3. *Stream or River Valleys.*—They are long and groove-like, run gently down the slopes, and are generally penetrated or washed by a river. Lake-valleys belong to the river regions, with which they are connected, and are generally of like extension in length and breadth. That valleys have formerly been beds of lakes, is shown, in many instances, by the position of mountains, the direc-

tion of rocky layers, and, finally, by the nature of the soil. The Inn, in the Tyrol, enclosed between high Alps, was once a deep lake, and the present river Inn was then the outlet of that lake, running into a less deep and less enclosed valley than it does now. Bay-valleys are surrounded by land, without an outlet, or they open on one or both ends, and are directly connected with the ocean, or indirectly by straits. In high mountain-regions we find the valleys sometimes very high above the level of the sea, while lake-valleys in Scandinavia rise only from 2,300–3,600 feet; those in the Alps, i. e., the Engadine valley, from Zermets to the Lake of Sils, rises 4,400–5,600 feet, and the Aosta valley, as far as Lake Bernard, from 1,850–7,600 feet; and in the Andes, the valley of the Desaguadero River, as far as Lake Illimani, over 12,000 feet. In the Himalaya Mountains, the valley of Sutlej, or Sutlege, 20 English miles from its exit from the mountains, rises about 3,900–9,700 feet, and the valley of Spiti 10,400 feet.

Mountain-passes are depressions in mountain-ranges, or gaps across the ridges between precipitous sides. The lowest places on the Alpine ridges, which afford the easiest pass, are high mountain-valleys let into the rocky pyramids which crown the crest of mountains. Their longitudinal extension is in some places quite considerable; in others, scarcely more than a hundred feet. If roads lead through these defiles, then they receive the name of mountain-passes. In high mountains of Europe, these passes are generally to be found at distances of 10–15 German miles; in the mountain-ranges of second order, from 3–6 miles apart; and in those of third rank, from 1–2 miles, as a general rule.

MOUNTAIN-RANGES, IN REGARD TO HYPSOMETRICAL DIMENSIONS.

The usage of language has established noun-appellatives for the altitudinal rising of mountains, so that with a word alone a definite idea of the extent is conveyed.

1. Hilly land, undulated country, characterized by gently-rising eminences, with broad ridges, that wave-like run into each other, become flatter and flatter, and finally disappear in the plain. (See Plate XVIII.)

2. Spurs of mountains derive their name from being situated in advance of high mountains, and separated by wide valleys or low plains; they are very low and flat, with gentle slopes. The form of the principal mass is rounded off, with mounds rising up to the ridges. The foot generally disappears in the plains or large val-

leys. If traversed by rivers, they are intersected by them in so-called serpentine courses, with steep shores. (See Plate XIX.—Section of Canton of Geneva.)

3. *High land* is also generally called mountainous land. Sometimes the idea of high land is confounded with that of plateau. The characteristic of table-lands or plateaus is the general similarity of the surface level. High mountains, however, may rise from them, or they may contain deep and isolated valleys, and would consequently be more properly termed hilly or mountainous plateaus. High land rises even as high as 2,000 feet, and is of manifold formation, from gentle elevations to deep slopes. The bottoms of the deeper valleys of high land have already a greater absolute height; the relative elevations are from 600 to 1,000 feet. (See Plate XX.)

4. *Lower mountain-ranges* are partly independent mountain-ranges, partly offshoots of middle or high lands, and rise even to 3,000 feet. As independent mountain-ranges, their structure is manifold; as offshoots, the forms are broader.

5. *Middle mountain-ranges*, i. e., those situated between the Alps and the lower range are higher and steeper, the precipices more abrupt, the masses more isolated, imposing, with exact and distinctly-expressed outlines. The valleys are narrow, deep, and rocky. Whole parts are bare, or decked only with a thin cover of lichens, still preserving the outlines. Precipices of considerable height are often found in middle mountain-ranges. (See Plate XXI.)

6. *Alps* are strangely-rent forms, pyramid-like mountains of immense heights, surrounding a towering peak; the slopes deep, furrowed, jagged, rugged, confused, with sometimes nearly perpendicular sides, the whole a wild confusion of rocky peaks, abysses, chasms, and deep valleys, varied with far-ascending broad hollows (Mulden), and extended "Halden" (broad and gentle slopes), covered with the most luxurious Alpine grasses. (See Plate XXII.)

7. *High mountain-ranges* are still more precipitous and rough than the Alps. Abysses, with narrow bottoms, separate the colossal masses. The forms are striking and bold; their immense layers and strata leaning against each other in groups, like tumbled-down walls; the rocky forms angular; the torn peaks assuming the shape of needles, or horns, and mostly enveloped by clouds; the summit covered with eternal snow. In the valleys, which are enclosed between side-branches of high mountain-ranges, lie heaps

of stone, rubbish, and rocky fragments. The river bottoms and slopes are of considerable depth, and frequently nearly perpendicular. (See Plate XXIII.)

8. *Ice-mountains* are those which reach far above the limits of snow, away into the regions which enclose the loftiest Alpine peaks. Between ridges and jagged rocks (by means of reflected sunbeams and the heat thus created and the superficial melting of snow), originate the eternal dome-covered peaks and summits which are immovable.

The slopes, ravines, and clefts, covered with everlasting snow, feed the glaciers, which then partly fall over precipitous sides with a tremendous crash, or descend, slowly and steadily, far below the snow limits into the valley. From out the snow-beds, peaks are seen now and then; precipitous bare rocks, single or in palisade-like ridges.

9. *Giant Mountain-Chains.*—These embrace the highest mountains of the earth, as the Himalaya, the Andes, and Cordilleras. The former are mountainous masses, with many transversal mountain-chains, and not a mountain-plateau, as was long erroneously considered. No traveller has as yet succeeded in reaching the interior of Nepaul, to give us a correct description of the highest mountain. We may form an idea of the immense extent of these masses, if we consider that no pass is to be found in the mountain-chain below 15,000 feet, and that the peaks rise from 7,000 to 11,000 feet above the ridge. The peak of Mount Everest, 29,002 English feet, is twice as high as the highest mountain in Europe.

SOME ACCOUNT OF GLACIERS GENERALLY.

From a military point of view; the phenomena of glaciers are out of the sphere of observation, as troops will always avoid them; but in regard to many formations in mountainous regions, even at great distances from the theatre of glaciers, the topographer will find explanation only when he has become acquainted with the actions and conditions of glaciers of the present period.

Formation of Glacial Ice.—It is very well known that the highest mountains which rise above the line of snow are covered with perpetual snow. This snow, as it receives annual additions, would increase indefinitely in altitude were not its accumulations checked by the constant descent of a large portion of it by gravitation. It thus undergoes transformation, caused partly by

the sun and partly by the rain, and, by freezing over again, is converted into ice of different conditions, from a loose or compact opaque snow to a transparent solid ice.

If the cohesion of these masses becomes so strong that ordinary pressure will no longer separate them, they are denominated "glaciers" (Romanic, "Vedretta;" in Icelandic, "Jökul;" German, "Gletscher"). The ice of glaciers, in its origin, is composed of sharp-cornered crystals, from the size of a pea to that of an egg (see Fig. 5, Pl. XVI., a specimen three-quarters of the natural size), which separate more or less readily near the firn, and in the exterior crust of the glacier, and are linked together as if by joints. These can be easily recognized here, but in deeper and more solid ice they can be discovered only by pouring on some colored fluid, and some observers have failed even with this test. The absence of perfect transparency is caused by a great number of small air-bubbles that cannot escape from the frozen snow.

The structure of glaciers is described by Prof. J. Forbes as follows (see Figs. 1–3): It is observed that a ribboned structure, formed by thin and delicate blue and bluish-white bands or strata, which seem to traverse the ice in a vertical direction, or rather, which, by their apposition, has formed the entire mass of the ice. The direction of these bands was parallel to the length of the glaciers, and, of course, being vertical, they cropped out at the surface, and, wherever that surface was intersected and smoothed by superficial water-courses, their structure appeared with the beauty and sharpness of a delicately-veined chalcedony. Toward the sides or walls of the glacier, at its lower extremity, the veins have their plane twisted around a vertical axis, having now their dip toward the centre of the glacier, and rising against the walls, and this inclination sometimes extends nearly to the axis of the glacier, or the medial moraine, where the veins, deviating from the vertical by an angle of about 20°, the bands inclining from the centre (or rising toward the walls), as if the pressure arising from the superior elevation of the glacier under the moraine had squeezed them out. The phenomenon has a good deal the air of being a structure perpendicular to the lines of greatest pressure.

The extent of glaciers varies from a few hundred square feet to many square miles; their thickness is often many hundreds of feet. In regard to exterior attributes, glaciers may be divided into three classes: The first, being generally covered by loose or granular snow, are called firn-glaciers, and hang to high and nearly perpen-

dicular rocks; but if they extend over the whole ridge, descending on the opposite slope, they are called, in the Alps, "Joch" (ridge) glaciers, and, as such, form the second class. The third class, descending the valleys, are designated as glaciers of the first order, when located in a main valley, and those coming down from the side-valleys as glaciers of the second order. Their inclination rises as high as fifty degrees in the latter; but those of the main valleys have but little inclination, as, for instance, the Mer de Glace, near Chamouni, only three degrees.

The surface of the ice is rough; in consequence of its unequal density, some parts melt quicker than others. Where the glacier rests on a level ground, it generally forms an unbroken plane; but where the ground is shelving, or uneven, the mass of ice cracks vertically in many places. These fissures, or crevasses, are always perpendicular to the conical surface of the veined structure, and are in width sometimes very small; often, however, they widen into abysses, which can be passed when covered by snow, or by artificial bridges. They seldom extend through the entire width of the glacier, though their length differs from a few feet to a few miles. The depth also varies much, and sometimes descends to the ground of the valley. By the partial destruction of these fissures, when densely crowded, the surface of the glacier forms scenery of the wildest description imaginable.

The motion of the glaciers is slow, but uninterrupted, which becomes apparent from the fact that, while the ice is visibly melting away, the points of termination remain for many years stationary, or even advance. A still better evidence is given by large pieces of rock, which fall upon the glacier, and are gradually carried toward the frontal dip.

The mass of the glacier, moving down a valley, follows all turns and windings. If the valley widens or branches off, the ice does not divide, but generally follows in the direction of the strongest pressure. By a junction of two glaciers, one is somewhat pushed from its course by the other; but both unite into one mass, in which the line of separation running downward remains visible at a great distance.

The chief motion of the glacier is, of course, during the warm season; but, as already stated, is also observed to move during the winter season. According to observations, by Forbes, on the Montanvert, in 1842, the average motion of the lower glacier amounted to 16.7 inches per 24 hours; at the upper part of the same

glacier, to 10 inches. The law of motion is found to be exactly like that of running waters; it is more rapid in the middle of the frozen stream, and slower at the edges, according to friction; it also moves faster on the surface of the glacier than in the interior.

We quote from L. Agassiz's work a statement of the progress of blocks, fixed in the ice for observations, with special regard to the motion of the section called Station du Pavilion (see Pl. XVI.), as given for various years:

In 1843, the advance of the blocks was from about 2 metres minimum to 66 metres maximum.

In 1844, 22 metres minimum to 87 metres maximum.
" 1845, 24 " " " 76 " "
" 1846, 35 " " " 80 " "

An average per day of from $\frac{1}{100}$ to $\frac{1}{4}$ of a metre.

Erratic Phenomena in the Alps.—In early days, the attention of men of science had been directed to a series of phenomena designated as erratic, and originating in the Alps. To these belong, in particular, blocks of granite and heaps of unstratified rubbish, mud, sand, and pieces of rock, with which the glacier was loaded, but which are entirely foreign to the soil where found. They were noticed, and attention was awakened; but they remained a mystery until Swiss geologists of the present day discovered their connection with the glacial movement of a former period.

These erratics, composed of all sorts of minerals, and of smooth, polished, furrowed, and angular surfaces, are observed in the Alps at a great height above the present glaciers, and far below their actual extremities; also, in the great valley of Switzerland, fifty miles broad; and, almost everywhere on the Jura, a chain which lies to the north of this valley. The average height of the Jura is about one-third that of the Alps, and is now entirely destitute of glaciers; yet it presents, almost everywhere, similar moraines, and the same polished and grooved surfaces and water-worn cavities. The erratics, moreover, which cover it, present a phenomenon which has astonished and perplexed the geologist for more than half a century.

No conclusion can be more incontestable than that these angular blocks of granite, gneiss, and other crystalline formations, came from the Alps, and that they have been brought from a distance of fifty miles and upward across one of the widest and deepest

valleys in the world; so that they are now lodged on the hills and valleys of a chain composed of limestone and other formations, altogether distinct from those of the Alps. Their great size and angularity, after a journey of so many leagues, has justly excited wonder, for hundreds of them are as large as cottages; and one in particular, composed of gneiss, celebrated under the name of Pierre à Bot, rests on the side of a hill about 900 feet above the Lake of Neufchâtel, and is no less than 40 feet in diameter. (See Fig. 4).

The moraines are the glacial deposits constantly rolling and falling from the surrounding rocky bed on the glacier. These bowlders become separated by the effect of frost; for, whenever water penetrates into the cracks of rocks, they are bound to split off, and if the crack has a direction inclined toward the valley, it comes down with a thundering crash; otherwise, it rests in its place until an avalanche carries it away.

Every year the firn region of the glacier is covered with a new layer of snow, and in this is buried a certain quantity of loose rock-detritus.

These fragments generally will fall upon the glacier near the place of their precipitation, with little chance of sliding off, because, at the time when the separation of these rocks most frequently occurs, the snow into which they sink is in a soft condition. Only small fractional pieces, such as earth, sand, or dust, are sometimes driven by the wind to more distant parts of the firn-field. The edges of the firn-mass become thus covered with stones of various sizes, but sometimes they are thrown farther into the firn, and, being isolated on the glacier, pass through a process whereby they become, in appearance, perfect tables; hence their name, glacier-tables. This is explained by Forbes in this way: In conformity with the known fact of the waste of the ice at its surface, the glacier sank around the stone, while the ice immediately beneath it was protected from the sun and rain. The stone thus appeared to rise above the level of the glacier, supported on an elegant pedestal of beautifully-veined ice. On the 6th August, the pillar of ice was thirteen feet high, but by the progress of the thaw it slipped from its support, and in the month of September it was beginning to rise upon a new one, while the unmelted base of the first was still clearly visible upon the glacier; and this progress repeats itself until the stone arrives at a moraine. Other materials, such as earth, pebbles, etc., lying on the glacier, become heated by the

rays of the sun, and, melting the ice below, form a hollow, especially if the ice is covered with a thin layer of earth.

By the constant motion of the glaciers to lower regions all such loose objects must finally be deposited at the sides or at the dip of the glacier. The masses deposited along the embankment are called side-moraines; those collected at the dip, and which form a kind of barrier, are called end-moraines.

The material of the moraines is not only remarkable for its manifold formations, but large angular blocks are found by the side of rounded and polished forms, surrounded by sand and clay. The first come from the surface of the glacier mostly, the rounded ones were transported underneath, or along the embankment, and are named ground-moraines. A large portion of these rocks precipitated under the glacier's surface, does not resist effectually the grindings they are there subjected to, for, before the journey is ended, they are perfectly ground to powder, which is called glacier-clay.

Smoothed and still more polished or furrowed surfaces of rock are an important evidence of erratic phenomena. They are the result of the action of the glacier. Ice alone is not able to produce such astonishing results; it could only take away some of the movable parts of rocks on its way. The smoothing and polishing of rocks is done by the friction of the bowlders along with sand and pebbles. By the same process, one of these embedded stones, being so much harder, works those remaining traces, as a burin would do, by the immense power of the moving glacier. Generally, such polished marks are found where the glacier is forced through a narrow passage. Such smoothed or grooved rocks are found 2,000 feet above the present level of glaciers, and also bowlders, which, consequently, were recognized as side-moraines. This proves, as an undeniable fact, that ancient glaciers once filled up the valleys to that altitude, and, consequently, must have an adequate extension, which has been also sufficiently proved in places where, at present, the formation of glaciers is extinct.

It has been stated that the bowlder formation, and all the attendant phenomena of striated and dome-shaped rocks and far-transported erratics, become more and more conspicuous in proportion as we extend our survey to higher latitudes. We find, for example, a characteristic display of them in Norway, Sweden, and Denmark, the southern borders of the Baltic, or Northern Germany, Russia, and Finland. They are also observable in the mountainous

regions of Scotland, Wales, and of the British Isles generally. In the Western Hemisphere, both in Canada and as far south as the fortieth and even thirty-eighth parallel of latitude in the United States, we meet with a repetition of all the peculiarities which distinguish the European bowlder-formation.

APPENDIX.

A BRIEF SUMMARY UPON RECONNOITRING.

FROM O'ETZEL'S WORK UPON "TERRAINLEHRE."

MANY highly-useful books, in French and German, have been written upon this subject, concerning which, nevertheless, General von Decker says: The majority evince a too micrological bias, and an insupportable prolixity, as also a tendency to completely forget that there is a considerable difference whether reconnoitring is to instruct the reconnoitrer, or whether the reconnoitrer is to afford any knowledge of the ground to him at whose command it was undertaken.

If the reconnoitrers are, moreover, men of letters, who delight in an inflated style, touched up with variegated flourishes of topo-oro-choro-and-hydrographical lore, the object sought to be attained could not more wretchedly miss its aim. This is an error very likely to arise—consequently, a note of warning is not out of place.

Field-reconnoitring, if to be of practical usefulness, must be replete with results—stern, dry results—and contain as few digressions or embellishments as possible. The general's object being to learn if such a road can be taken, such a stream bridged, if this or that position is propitious for an offensive or defensive purpose, that of the reconnoitrer is to send in short and intelligent information. He who fills up a whole sheet, where half or even a quarter of a one would suffice, bores his commander with just so much waste-paper.

Staff-officers are invariably intrusted with all important reconnoitring, which constitutes the most essential part of their vocation. Therefore, to be the more carefully studied, these jottings, consequently, are not addressed to them—but to officers and engineers, who have had hitherto no opportunities to make reconnoitring a specialty, but who, nevertheless, the occasion arising,

might be detailed for such duty. But, as our own experience has taught us, at the military academy even, the instructor in "Terrainlehre" (that branch which treats of all conditions of the earth's surface) only refers *en passant* to the subject, which is also the case in theoretical tactics. The instructor in surveying teaches the use of the plain table, and confines himself to geodetical matters; neither in the drawing-lessons are the technicalities of the subject touched upon. Thus, with the exception of the higher course of instruction of officers, special instruction in this department is not afforded. It is, however, expected that he who pursues the above-mentioned branches will be qualified to accomplish the task, as these branches constitute the sum total of the qualifications necessary.

As far as the civil engineer is concerned, reconnoitring connects itself solely with the proposed surveys; in what relates to the most propitious stations for the plain table, or when he has to run a line, at the points of transition, over streams and mountains, or to avoid swamps, or spots liable to inundations.

The manner of reconnoitring has to be modified according to circumstances, such as the length of time at one's disposal, presence or absence of the enemy, the special object in view, etc.

The object sought to be obtained in reconnoitring is:

1. To inquire and examine the country in regard to the practicability for marching-purposes.

2. To examine the terrene in regard to the combat, viz., its practicability for battle-ground.

3. To examine the country in regard to the subsistence of troops, viz., its advantages for their general well-being.

The relations of objects searched for are comprised in these three principal considerations:

1. The junctions of roads and streams.

2. The propositions offered.

3. Statistic remarks relating to subsistence.

A regular military survey is out of the question in reconnoissances. Such work can only be performed in time of peace, but it is a twofold preparation for war, as it produces correct maps, and thereby qualifies the persons to execute said reconnoissances.

Practice in the different branches of practical surveying is surely the best means to perfect a reconnoitrer: he acquires a

routine in observing the practicability of a terrene for military purposes, and, in particular, he distinguishes those points from which the best observations of the country can be effected; he becomes qualified to estimate distances and proportions of opposite positions, brings his eye into practice, and finally achieves, by so doing, a greater and certain facility in representing a terrene by drawing than in any other way.

From these remarks, however, a conclusive supposition dare not be made, that every one who is capable of producing a correct and well-drawn survey possesses all the faculty and the accomplishments for practical reconnoitring. It is possible that somebody may execute, with great pains and waste of time, a perfect survey of any part of a terrene section, so that nothing therein is lost sight of, and every detail even be carefully laid down, and nevertheless be unfit for reconnoitring.

If we look closely into the purpose of the reconnoissance, and consider the capabilities requisite, we see clearly that, if reconnoitring has any military importance, those who have to effect it must be thoroughly educated and practical soldiers, in the fullest sense of the word. It is not sufficient that he be experienced in the rudiments of tactics, he must also be acquainted with a diversity of things and doings, which are not directly tactical; i. e., what impedes wagons on the march, what gains of time may be achieved by reparation of roads, by building a bridge, and such like—whether the time sought for will be obtained—whether the gain of time is in proportion with the work to be done—that it really is of use to the operation, and so on.

A reconnoissance is either an observation of the terrene for the officer's own use, or it is to serve for an oral or written report, or it is a cursory view (a *coup d'œil*) of the terrene. Often a sketch will be combined with the description, and this renders the report more explicit and comprehensive.

One of the principal points in reconnoitring is to ascertain distances, and this is obtained either by measurement or by estimate.

The simplest mode of measuring is pacing, i. e., measuring by steps. Thereby, the greatest care is necessary to avoid mistakes, in the counting of the paces especially, since the surrounding objects are apt to divert the attention. It is convenient to mark certain subdivisions, for instance, every hundred paces, by a pencil-stroke, or by transfer of pebbles from one pocket to the other, etc.

Measuring on horseback is more expeditious, a mode of convey-

ance usually employed in the operation, not only for saving time, but also as offering a larger field of view to the observer, especially where obstructions prevail. In both cases, the exact length of a certain number of paces has, of course, to be tested, which is done by repeatedly going over a measured distance, and striking the mean of the number of paces counted in every passage. The use of the horse admits of different gaits—the pace, the trot, and the gallop. The former two are counted by double steps, the latter by leaps.

Another way of measuring distances is by timing them; that is, by ascertaining the duration of passage over a definite space at a certain gait. This knowledge may be obtained by combining time observations with the above-mentioned test of length and number of steps.

This mode of measuring has this great advantage, that all the attention may be concentrated upon the examination of the surroundings, provided the speed is kept up to the standard test, and stops, when necessary, are duly taken into account.

It is presumed that every officer or field engineer is acquainted with the extent of his own pace, and knows the difference between an upward and downward stride.

After repeated trials, one can reckon how many human paces, in a given time, can be gone over, as well on foot as on horseback. It would be a useless waste of time to count the number of strides a horse can travel, as they must be reduced to human paces. By this means data are determined which are easily retained; for instance, the author in one minute can strike off 100 paces. One of his horses can travel:

At a walk,	120	human	paces	per	minute.
At a gentle trot,	180	"	"	"	"
At a strong trot,	240	"	"	"	"
At a gallop,	300	"	"	"	"

Another of his horses:

At a walk,	105	human	paces	per	minute.
At a gentle trot,	150	"	"	"	"
At a strong trot,	250	"	"	"	"
At a gallop,	290	"	"	"	"

This way of measuring has this advantage over counting the paces, that one's undivided attention can be directed to the objects to be noticed, only taking care not to stand still without taking

note of time. If a stop-watch is made use of, the exactness will be certainly increased. Still, the object sought can be attained, in all its exactness, for it is really possible to tell off quarters of minutes, by means of an ordinary watch, and, after a few trials, but few paces will be lost.

As such errors of observation will not always be of one kind, that is to say, that at times too many, at others too few, will be marked off, such errors will be compensated in the course of a protracted task, and will be almost imperceptible.

For jotting down the measured distances, paper ruled crosswise is commonly used, where one side of the rectangle represents the length of 300 paces, the other of 400, and its diagonal, accordingly, 500; or the paper is divided into squares of 500 paces in length, when the diagonal becomes 707 paces. Such paper has this great advantage that, in the sketch, the distances are at once legible without requiring measurement.

As it would be an obvious loss of time to actually measure every distance, it will therefore suffice if the situation of such objects which are not on the road of the reconnoitrer, but are visible from different points, be determined by measurement in taking the angles.

The instruments adapted to this purpose must be simple, durable, and portable, because they are often to be used on horseback.

Since the experience gained by practical surveying is considered essential to success in reconnoitring, a sufficient knowledge of the usually-employed instruments may be presumed, and a detailed description dispensed with. We will only name them, and briefly indicate their differences.

There are three instruments most frequently used for this purpose: 1. The Reflector. 2. The Patent Compass. 3. The Sketching Planchette.

1. *The Reflector* has this advantage, that the measured angle may be either graphically transferred or read in degrees and minutes. Its vernier allows the reading of two minutes. But this great accuracy is scarcely available, since our simple and rapid measurements will rarely admit of the complicated corrections for collimation, and the error arising from the difference in height of the observed objects; thus the possible errors may be as great as those occurring by using the compass.

2. *The Patent Compass* requires, like the reflector, a separate planchette; but, besides this, a protractor is necessary for deline-

ating the measured angle, and thereby the liability to error is increased. Another disadvantage is caused by the disturbing influence of the surrounding objects upon the magnetic needle, so that some formations, such as basalt, greenstone, etc., make its use entirely inadmissible.

3. The sketching-planchette, together with a common box-compass, is the most simple of the mentioned instruments; and the practice necessary for keeping the compass in a suitable position, while taking sight of distant objects, is certainly just as easily obtained as the skilful manipulation of reflecting instruments.

In war, but few measurements can be made, for want of time, and distances as well as angles have to be estimated. This requires a well-practised eye; and though of course a sound organ is to be presupposed, the necessary faculties of judgment and imagination can be considerably developed in almost every individual by a systematic course of exercises.

CONCERNING THE ESTIMATION OF DISTANCES BY OPTIC MEASUREMENT.—CAPTAIN F. VON BAUR.

The special condition of the eyes of an observer causes, in the estimation of distances, differences of considerable importance; thus, each individual must fix the particular principles which experience has laid down for his vision. The laws of optics, too, will none the less work a modification in estimating distances. Garish prints and light colors appear nearer, especially on dark ground; dark places, sombre colors, any bedimmed light, increase the distance of objects.

A clear, dry atmosphere reveals every thing with more distinctness, consequently nearer, than wet, misty, or very hot air. Large uniformly-colored plains, water, snow, and the like, sensibly diminish the distance. High objects present themselves nearer, small objects more distant. Here the comparison of known with unknown magnitude can alone supply an estimate basis. An object is lost to sight so soon as it is 6,000 times farther off than the greatest extension of its own length amounts to. Widths are better estimated if an equilateral triangle is formed by the eyes and extreme points.

Estimation of distances on perceiving troops, with ordinary good eyes:

At 2,000 paces.—Movement and flash of weapons. Is cavalry in the distance, the files are perceived, without however knowing whether mounted or dismounted.

At 1,500, Infantry-files are perceived; horses of the cavalry now come into view. With a dim light, a herd of cattle has nearly the same effect.
" 1,000, The line of heads and movement of legs.
" 800, The upper portion of the body. The movement of the feet is more distinct.
" 600, Head and head-covering becoming distinct—color of coat.
" 400, Color of facing—shako ornamentation.
" 300, The visage.
" 200, Buttons and braiding, etc.
" 100, Eyes as points.
" 30, The whites of their eyes.

Estimation of distances by recognizing known objects:

At 250–300 paces, Tiles of roofs.
" 600–800, Window-sashes.
" 1,200–1,600, Rafters, smaller stems of trees, sign-posts.
" 2,500–3,000, Large trunks of trees.
" 4,000–5,000, High chimneys.
" 3½–5 miles, Small houses.
" 10–15 " Windmills.
" 20–30 " Churches and castles.

In one second, the report of a gun travels at the rate of 1,300 feet; in general, it is estimated at:

With a clear atmosphere and favorable wind,	500 paces.
" dull, quiet atmosphere,	450 "
" misty "	400 "
Against wind,	380–400.

In comparing the flash of a cannon with the time of the arrival of the report, the distance of the first can be measured. Should the watch not denote the seconds, an estimation can be made by an ordinary watch, which generally ticks four times in a second, or according to pulsation.

The report of ordnance is heard, under favorable circumstances, at a distance of thirty to fifty miles. With a contrary wind, pistol-shots are heard at one thousand paces, not more. Forests, hills, houses, and the like, increase the report; snow, water, etc., decrease it.

From the above it is evident that the estimation of the distance of an object from the stand-point of the observer is only possi-

ble when he has, at least, an approximate idea of its size, build, and color.

The conditions are the more favorable if several objects at different distances can be seen at the same time. A single object in a distant, monotonous plain, viewed, for instance, over a sheet of water, seldom gives a correct result.

If several objects are in view, involuntarily the relative distances are estimated; thus these questions are self-asked: Is yonder object two, three, or four times as distant as this one? or can I subtract such and such objects from others? And the attainment of the result is an excellent exercise wherewith to sharpen one's power of optical measurement. Another important object in optical measurement is to estimate the angle of inclination. The easiest way to do it is to take a position sideways of the declivity, and imagine, as it were, a profile across; straight trees and other perpendicular objects are of great help, the complement to the right angle being more readily and correctly estimated.

A front view of the slope will only in the greatest proximity allow of a reliable judgment, for, at a distance, all declivities look pretty much alike, especially when not relieved by light-colored objects. In all cases a bright light is of advantage to the operation.

The best exercise in estimating angles of inclination is the measuring of a great many. For this purpose a square piece of board is most convenient, upon which, from one of the corners as centre, a quadrant is struck, and perhaps subdivided from five to five degrees. From the centre a plumb-line is suspended as an index. Now, in taking sight along one edge of the board (toward the fixed centre, when looking upward, and from it when looking down the slope), the index remaining plumb, this edge will be parallel to the slope, on care being taken that the object looked at is of equal height with the eye of the observer; the angle thus indicated will correspond with the inclination to be determined. For reading off correctly, the plumb-line has to be kept in place by a pressure of the finger.

To readily find one's position is another essential requisite in reconnoitring. In general, the position may be only indicated by the points of the compass, or, within more restricted limits, by the mutual relations of the objects or parts of the terrene. Both these means, however, are conjointly to be applied for a full and perfect determination of any locality; and the points of the compass,

at any rate, have to be ascertained at the outset. This can be done in different ways:

1. *By the box-compass* generally used in reconnoitring.

2. *By astronomical means:*

a. By the sun, which, however, does not rise and set due east and west but at the times of equinox. At all other times these points are variable, and the culmination at noon is the only always reliable datum. Yet its observation is too complicated for our purpose, and restricted to noontime only, and it is better to extend the opportunity of observing by the aid of a watch. For it will be found sufficiently accurate to consider the sun's place nearly due east at 6 A. M.; southeast at 9 A. M.; south at M.; southwest at 3 P. M.; and west at 9 P. M.; and at intermediate times its position may be estimated. The difference of mean and solar time, and even some irregularities of the watch, will not affect the result injuriously.

b. By the Pole-star, which, from its close proximity, may be taken for the pole itself. Being easily found, and in clear weather visible from sundown throughout the night, it offers convenient means to find one's position at night. The Pole-star (Polaris) is in the extremity of the tail of the Little Bear (Ursa Minor), and in a straight line with the two stars of the Great Bear (Ursa Major), called Pointers, because they usually serve as guides when looking for Polaris. The Pointers are the two extreme stars of the trapezium of the Great Bear, which is popularly known by the name of the Dipper. The north point found, there is, of course, no difficulty in finding the other points of the compass.

There are other means for taking bearings, which, however, are less reliable than those given, and which can only come into play as a last resort. Thus, wind and rain generally issue from a certain quarter, more often from the north than from the west; that is why that side of objects (standing apart) which is exposed is called the weather-side.

The following means are also sure, if necessary:

1. In sparse forests the weather-side is known by the bark of trees being on that side coarser and thicker, and more moss-covered, than the other sides. In trees cut down the tops of the stumps show the circles narrower together, so that the heart lies nearest this side.

2. Bowlders are often grown over with moss on the weather-side, the ground under the same is especially damp.

3. Ant-hills are covered at the north side with grass and moss, but not at the south side, because the little animals keep that clear, so that the larvæ may receive the benefit of the sun.

With the assistance of a map, of the correctness and completeness of which we are fully convinced, it is easy to find one's position if we only know two points in the terrene, or have only one point and the cardinal points. Are we, however, not in possession of a map, or of only an unreliable one, then it is inevitably necessary to make inquiries, and procure a guide well informed in the country of observation. The best-qualified guides are those who, by their line of business, become acquainted with the country people well versed with the terrene in question; as, for instance, hunters, cattle-dealers, butchers, mail-drivers, carriers, etc. If we cannot find any such, we have to engage one from the village. With these men, of course, inquiries become more difficult than with those mentioned above. Ignorance, fear, mistrust, indolence, and not seldom ill-will, the latter, particularly, in the enemy's country, are the most difficult to manage, as they too often evince qualities inimical to our purpose, if not a mere ignorant stubbornness difficult to overcome.

The quality the most requisite, and one in fact which is indispensable, is cool, calm patience; we must, before all things, put our questions in such shape that they will readily frame themselves with the simple range of thought of such people. Avoid putting questions which can be answered with a curt yes or no; better let them expatiate at any length after their own fashion. In all important questions, or when any doubt exists as to their proper solution, beat round the bush, so that the guide be led once more to the subject without noticing that he has already answered that question; his reliableness will be here demonstrated.

Generous treatment is a sure means to open the mouths of such people, especially when a drink or something to eat has set them in trim to unbosom themselves. The promise of a reward at the end of the journey, added to a hint of punishment in case of deceit, will have a salutary effect. Relieving messengers from place to place is attended with advantages and disadvantages. It is unpleasant to exchange a good guide for a fresh one, with whom the business of becoming acquainted has to be all gone over again; on the other hand, such folk are apt to know with certainty nothing of the country, or, at most, are acquainted with but a short distance from their dwelling-place, and, with the best of will on their

part, are dumb to all questioning. If you have really laid your hand on a good fellow, but one whose knowledge beyond a certain region is restricted, it were well to retain him, subject to conditions, and to supplement his deficiencies, with regard to details, by taking an additional guide from place to place.

For carrying out a reconnoissance, a detailed prescription cannot well be given; it cannot, as it were, be compassed into a formula.

The study of maps, which, in war operations, will almost always be at hand, is certainly the best preparation before starting for a successful reconnoitring. A general insight into the characteristics of the terrene being thereby gained, it will be easy to proceed more systematically in accordance with a preconceived plan, and thus not only time will be saved, but the result will be far more complete and satisfactory; of course, we have first to examine the map before we can rely on it.

The Examination of Maps.—After having considered the different means employed to procure the topography of a country, with more or less exactitude, according to circumstances, it remains to inquire in what manner the topographical maps which can be procured are to be examined and proved.

If the time permit, the correctness with which the position of the principal point is laid down may be ascertained; but if it be not possible to attend to these details, the different parts of the map must be distributed to experienced persons, who, by passing over the ground within their reach, may judge sufficiently of the accuracy with which the work has been executed, and decide upon the degree of confidence to which the drawing is entitled.

If circumstances do not admit of employing this method, there is no other mode of deciding them; but by experience this may be acquired by all who desire it, for it is only necessary to become accustomed to read topographical charts, to make a frequent use of them, and penetrate their views by a comparison of the draught with the objects it is meant to represent. In this way the power of distinguishing false, negligent, or mannered drawings, from those that are correctly taken from Nature, is speedily acquired.

For example, the banks and sides of valleys commonly correspond in such a way, that the draughtsman cannot deviate from their general form without being detected by an experienced eye, and even the figure of minute parts, and partial accidents, produced by similar causes, must everywhere present themselves under aspects differing only by slight modifications.

The propriety of the order, time, and circumstances, is determined in the manner which will be pursued in making use of the map.

If a sketch is to be drawn, to mark the positions of troops, the corresponding portion of the map has to be enlarged to at least 1 : 20,000, which scale will serve to distinctly delineate even a battalion, without inconveniently extending the drawing. The more reliable the map is, the more we may copy of details; but is the map unreliable, then only the most salient points should be taken at first, since additions can easily be made, whenever these data are found to be exact. The paper has to be ruled into squares, as previously described.

Thus provided with the prepared sketch, a map, and, when possible, accompanied by a person familiar with the country, the reconnoitrer sets out for some prominent point, a mount, a steeple, or other high building, etc. Is none of these in the surrounding neighborhood, then compare your map and sketch with Nature to the right and left on your way, and correct all inexactness, observing in particular all objects lying in one direction (alignement), and examine the map thereon.

Arrived at the site chosen for the prospect, place your map in accordance with the four cardinal points, or with any salient or striking natural object, and proceed now to verify the accuracy of the site of the places according to the angles which they make with the station you occupy.

At the same time, seize the occasion to form a general idea of the character of the terrene; the more important points you intend to strike are recognized, and distinguish the localities which, in order to know their peculiarities, need not be gone over.

What we have here seen must now determine our further progress. If we discover, for instance, another high point from which the country beyond can be seen, we shall have to reach it, to distinguish again the objects worthy of note as we proceed; the shortest cut is not always one whereby the most time is saved.

As we have a good map, we can confine ourselves to the immediate inspection of the most striking objects; and that which by actual distance is of less importance, can be mapped off by optical measurement.

Description of Terrene.—A mere description of terrene, without any graphical representation, can scarcely be given so as to convey a definite idea of the unknown country to the reader. This could

only be accomplished when, at the expense of much labor and time, the description would be made so minute that a drawing could be taken from it, which would be actually necessary whenever a clear and distinct image was desired.

The first rule for such a description is, the utmost brevity, without the omission of any thing important. This, and the necessary clearness, will be best obtained by rendering the subdivisions conspicuous and logically arranged. When describing larger districts, it will be well to give, concisely, a general outline as an introduction; then a subdivision may follow into such sections as the nature of the configuration indicates; and, lastly, the details may be entered upon. Such an arrangement will have the advantage that the first received general impression will be left undisturbed in the reader's mind, not affected by the amount of details necessarily crowded into the description of the several parts.

Drawing and Description combined.—We have just said that even the best description of a terrene could give no satisfaction without some kind of illustration; but now we propose to recommend the graphical representation as a basis, only to be perfected by concise verbal explanations.

Such representation shows the characteristics of a country at a glance; plans and descriptions can be made understandingly; troops can be directed to positions with a few words, and no mistake to be feared, etc.; and, besides, the time for making them is much less than that required for an elaborate description.

Of all representations of a country, this kind is the most conformable to the purpose, and the advantages which they afford in warfare are manifold. For instance:

1. They are finished in less time than a good description.

2. They explain and display the representation more exactly and comprehensively than a mere word could do.

3. They give a prompt and a better general view.

4. The comparison of such sketches with Nature are more easily accomplished and in less time, etc.

The combination is twofold: either the description is disconnected, independent in form, as it were, or the explanatory notes find their place on the drawing itself. In the latter case, care has to be taken not to overcrowd the sketch, since it frequently has to admit later additions, such as positions of troops, fortifications, etc.

THE END.

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